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Kidd Creek Mine

TGS goes north to find a zinc-copper-silver bonanza near Timmins

TGS
Texas Gulf Sulphur Company

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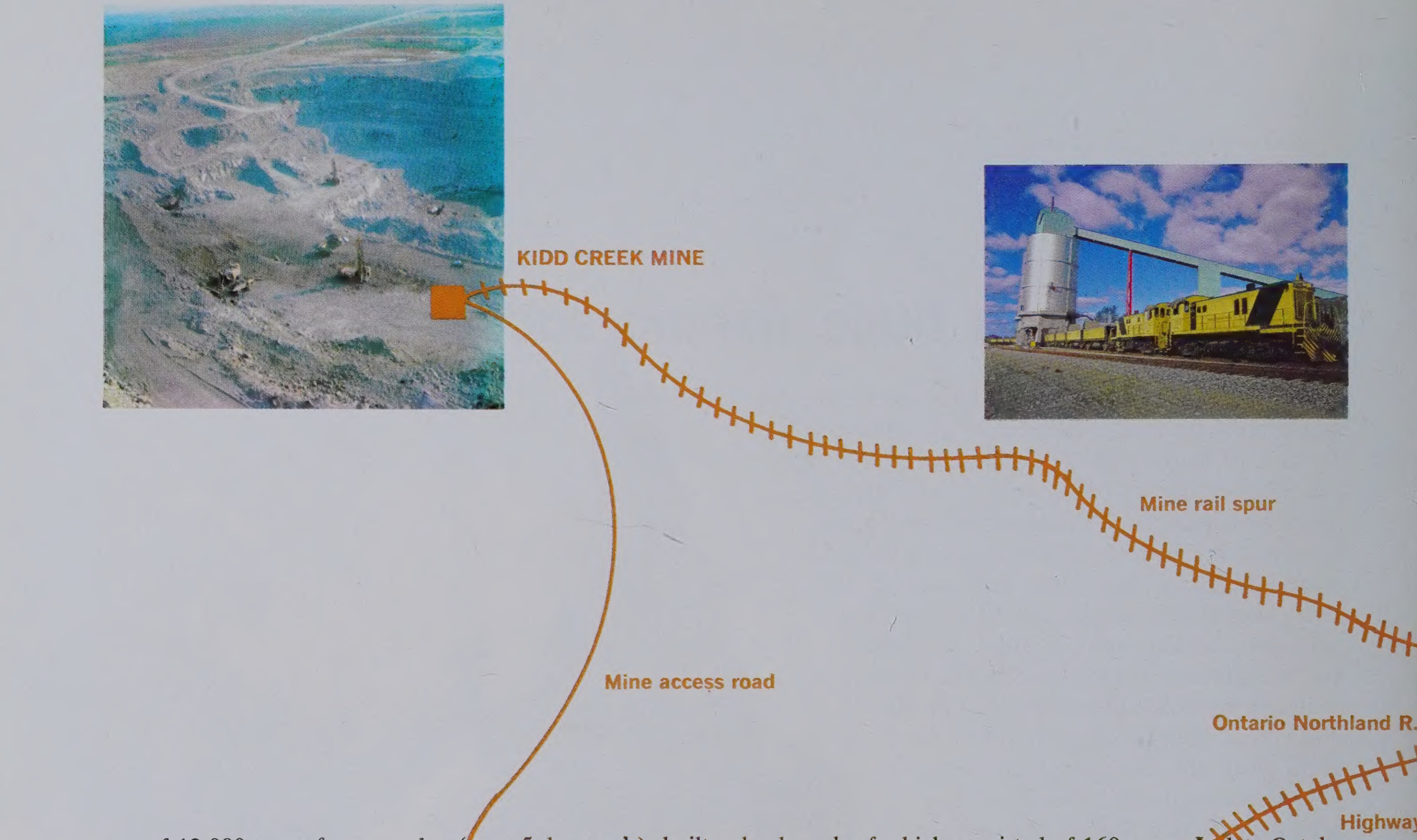
Kidd Creek – a huge mining success in Ontario

Finn B. Domaas, Associate Editor

No single base metals event in recent decades caused so much initial stir and sustained such excitement as did Texas Gulf Sulphur Co.'s 1964 discovery of a huge and valuable deposit of zinc, copper and silver beneath the muskeg near Timmins, Ontario. The sensational strike, just 15 miles north of the old gold center, triggered the wildest land rush in the area's long mining history, caused a flood of activity on Canadian and U.S. stock exchanges, and transformed Texas Gulf Sulphur from a company specialized in fertilizer minerals into a broad-based mining giant. In the five years since the announced discovery, TGS, operating through a wholly-owned subsidiary, Ecstall Mining Ltd., has put the open pit into production at a



rate of 12,000 tons of ore per day (on a 5-day week); built a heavily-automated streamlined concentrator that treats about 10,000 tpd of ore containing zinc, copper, lead and silver; and linked the two by a 17-mile railroad.

Many of the gold deposits mined in Ontario's Porcupine area intermittently for the past 60 years were discovered by chance. And ever since the first strike of any importance, prospectors have combed the swampy muskeg surrounding Timmins and neighboring settlements. How is it possible, then, for Texas Gulf to appear on the scene and suddenly pick out its treasure? The fact is, of course, that TGS did not suddenly emerge and did not pinpoint the Kidd Creek orebody by chance—it was the result of years of patient reconnaissance with an assortment of the latest exploration equipment and methods.

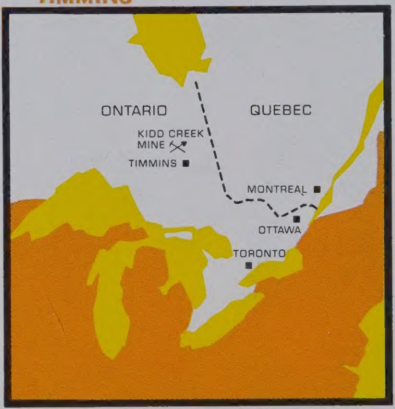
At the company's annual meeting in 1965, president Claude O. Stephens (now board chairman) reviewed the systematic exploration program that had been carried out in the Canadian Shield since 1957.

Because so many conflicting reports have circulated during the years since the Timmins find, and since what actually happened appears far more interesting than any of the other versions, here is a brief summary of Stephens' presentation to the stockholders.

After studying geological reports, Stephens said, TGS in March 1959 began aerial electromagnetic surveys with company-designed equipment in search of sulphide ores over wide stretches of the Shield. The more than 15,000 miles scanned during 1959, 1960 and '61 showed several thousand anomalies. Of these, Stephens reported, several hundred justified further testing on the ground. Some of these, including "Kidd 55," were on private land.

After negotiating for about two years, TGS in 1963 obtained an option for the purchase of the first of four plots of land, each of which consisted of 160 acres. In late October of '63, Stephens continued, company field crews carried out ground geophysical surveys to pinpoint a likely drill site. As with most of the area in that part of the Shield, the work site was covered with muskeg and only two small rock outcrops were located over 1,000 ft away.

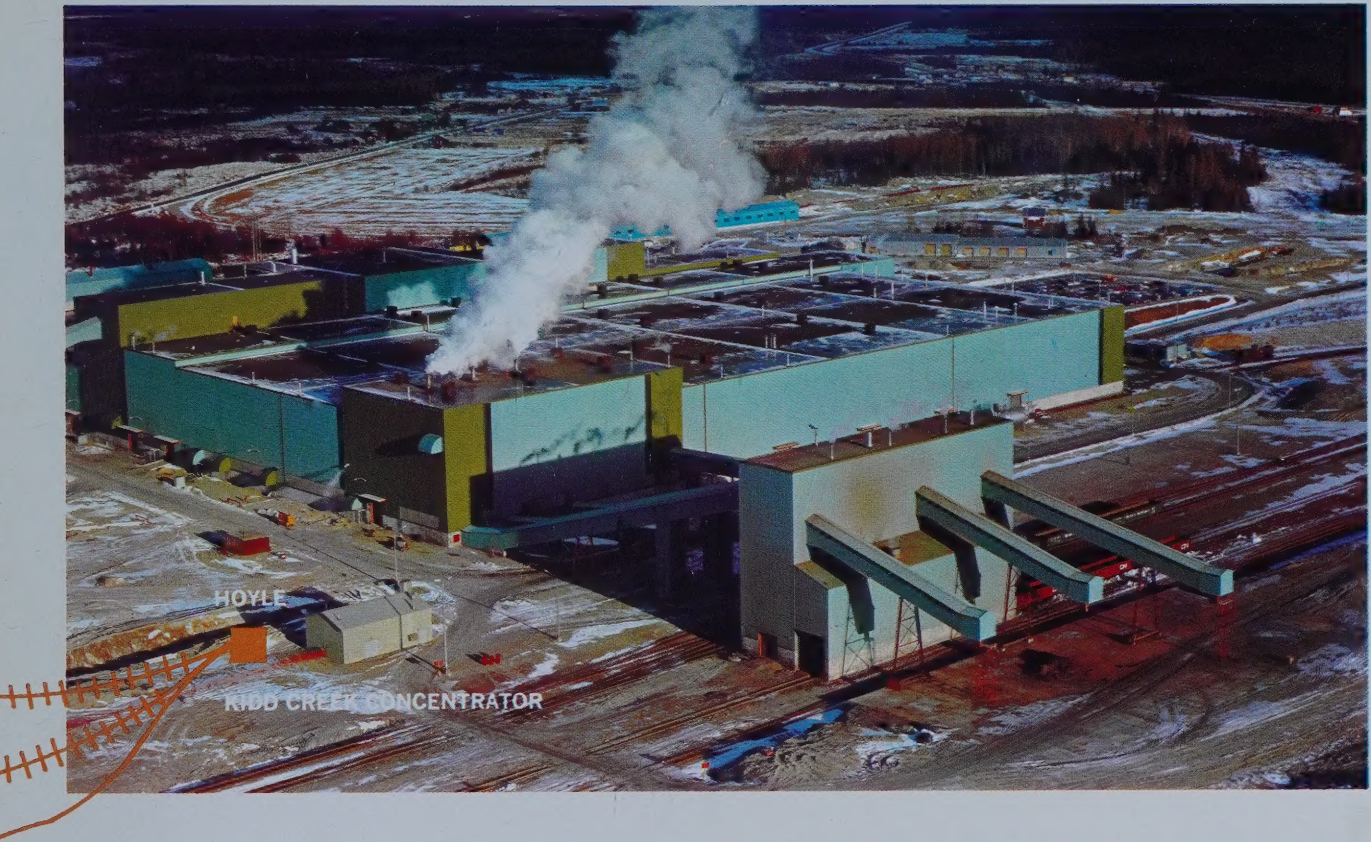
Though the crew pulled an initial core in November that showed zinc-copper mineralization, TGS faced a wide range of problems: the hole might have been drilled downdip; understanding of the area's basic structure was inadequate and speculative; the company had property rights on only 160 acres; it was uncertain whether or how far any mineralization went beyond the 160-acre tract; and the realization that an information leak could occur at any time.



While the first core was sent to Salt Lake City for assay, TGS kept trying to buy adjoining lots before any rumors could be triggered. At the same time, the field party covered over the first drill hole with a tree, moved to another corner of the tract to put down a blank hole, and then went on to drill another anomaly several miles away. As a further security measure, drillers were kept in camp as much as possible.

All these precautions paid off handsomely. By March 1964, TGS had bought all the tracts adjacent to the original drill site. The company feels that if any significant information regarding its core had become known to outsiders, it might not have been possible to obtain additional land holdings, and TGS would have had title to only the original 160 acres.

Various rumors concerning the Timmins project began circulating during January 1964. Then, after eight additional drill holes had been completed or partially completed, TGS on April 16 announced that it indeed had a minable body of zinc, copper and silver sulphide ore.



What Texas Gulf Sulphur actually found in 1964 was the final phase of a long and involved geologic history; beginning in the Pre-Cambrian, this tiny pocket in the Canadian Shield underwent varying cycles of deposition, redeposition, metamorphically-induced zonal enrichment, and, when uncovered by TGS, was a base metal concentration of enormous value. The orebody is, in fact, so rich and varied that the Kidd Creek complex is the largest zinc mine in the world, the largest silver producer in the world, a potential major source of cadmium, and that, when operating at capacity, its daily concentrate output surpasses anything in the world.

Contrasting the enormous success Texas Gulf is enjoying at Timmins are the uncounted and nameless prospectors who spent lifetimes searching through the Shield's muskeg, supported more by strength of will than a knowledge of ore deposition. Most were disappointed, and some died in the field. One of these, according to Timmins legend, spent many years searching for a super-rich lode he felt was nearby. He finally froze to death. His cabin and belongings (right) were seen by the first of the Kidd Creek mine staff; before it was destroyed, the small hut stood within a few yards of the pit's present primary crusher. For years, he had lived about 700 yards from where TGS eventually put its first drill hole, and about 100 yards from the deposit's southern limit!

The bedrock that once supported the prospector's cabin and now holds the primary crusher is the only sizable outcrop at the mine site. Because of this, finding a suitable location for the huge concentrator became a top priority assignment for the design engineers. They finally positioned it at Hoyle, 17 miles away, because the bedrock was adequate, water could be pumped from a fairly short distance, there was ample room for future plant expansions and a steadily growing tailings area, and, finally, trainloads of concentrates could easily be shunted onto tracks of the Ontario Northland RR.

However, for hauling ore from the mine to concentrator, Ontario Northland had to build a rail line through miles of muskeg and swamp. For almost the entire length of line, preparation of the roadbed called for cleaning out muskeg down to competent clays and glacial till, backfilling and compaction before the main ballast courses could be laid. In addition to the main rail line, marshalling yards at the concentrator took over 7¼ miles of track plus an enormous amount of switches and turnouts.

The entire mine-concentrator rail system is leased to Texas Gulf and is maintained and operated by the TGS staff.

If the muskeg was a major problem during the building of the rail line and the 15-mile road from Timmins to the mine site, it became a monumental one during overburden removal.

As with the rail line and road construction, the tedious job of stripping away the muskeg overburden was done as soon as Texas Gulf had the necessary land to carry out full-scale open-pit mining. The ore was overlain with soft clays to depths varying from 5 ft in the central area to 65 ft in the south and almost 95 ft at the northern limit. Nearly 7-million yards of clay and muskeg were stripped away to expose the 80 acres of bedrock.

Kidd Creek's clay pit is roughly 4,500 ft long, 2,300 ft at the widest point, and is bounded by a 2.37 - mile long perimeter dike. The rock pit is 2,600 ft long and 1,450 ft at the widest point. The long axis of the pit is north-south, with the main access ramp spiralling down counter-clockwise from the south end.

Before the pit went into production, the Kidd Creek staff had core-sampled its composition laterally and to depth. They soon discovered that though the mine was surely as rich as originally estimated, distribution of mineral values called for selective mining. Pit ore is segregated into two separate mill feeds; one type, "A" ore, is a copper-zinc mixture, while the other, called "C", is predominantly zinc ore carrying most of the silver and lead values. Generally "A" ore is fed at twice the rate of "C" ore.

Not only are there different type ores in the pit, but the grade of the individual components can vary as well. For instance, grade of both copper and zinc go from almost pure chalcopyrite and sphalerite down to economic cut-off grades. In order to get the best possible metal recoveries, Texas Gulf decided that a constant mill feed as close as possible to the average grade of the orebody would give the best results.

Therefore, the pit crew must constantly blend ore to maintain desired grades for the concentrator. To do this, the shovels and loaders, as dictated by the sampling of blastholes, must move about frequently.

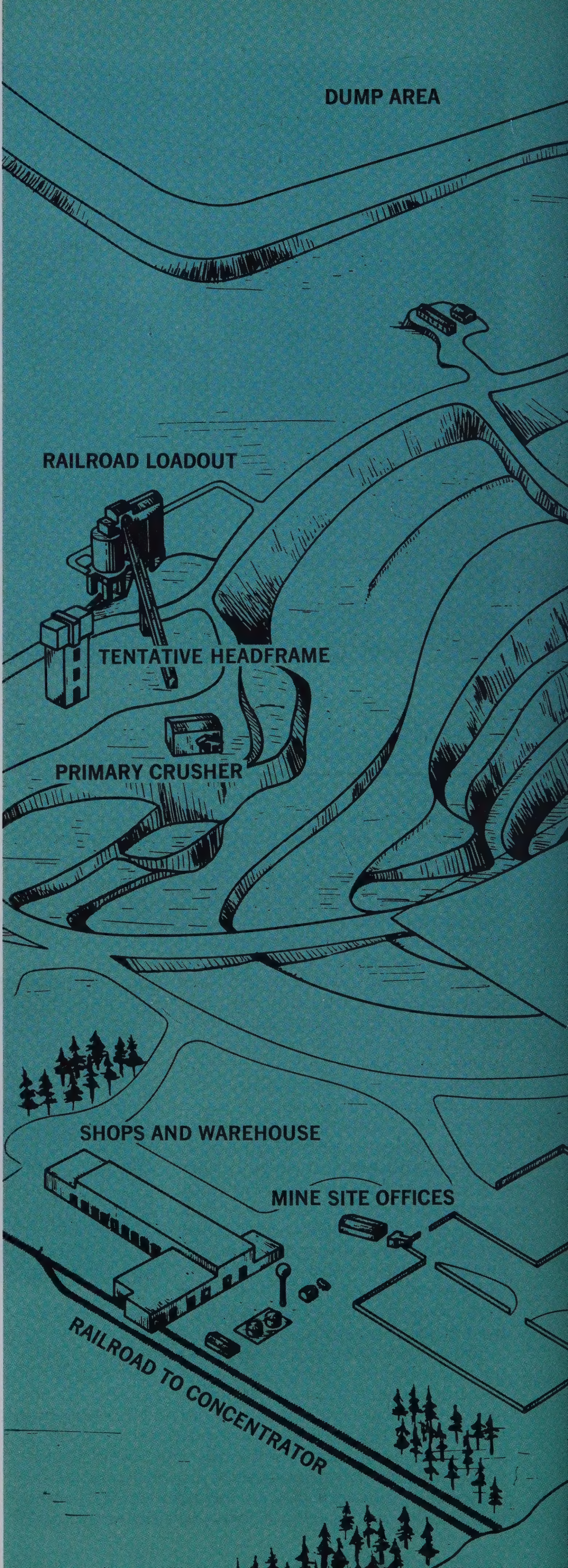
To tackle the pit's resistant rock, TGS experimented with many drill patterns and various explosives and loads. It finally settled on bulk slurry and AN/FO because, for Kidd Creek's conditions, it gives excellent fragmentation and has permitted the opening up of drill patterns.

After a bench is blasted, broken ore and waste are loaded into 50-ton trucks by electric shovels fitted with 4-cu yd or 6-cu yd dippers and front-end loaders with 6-cu yd or 14-cu yd buckets. Ore is hauled about ¾ mile to the primary crusher; waste is taken more than a mile to disposal areas near the pit. Rubber-tired dozers do general pit clean up while crawler dozers level waste rock at the dumps.

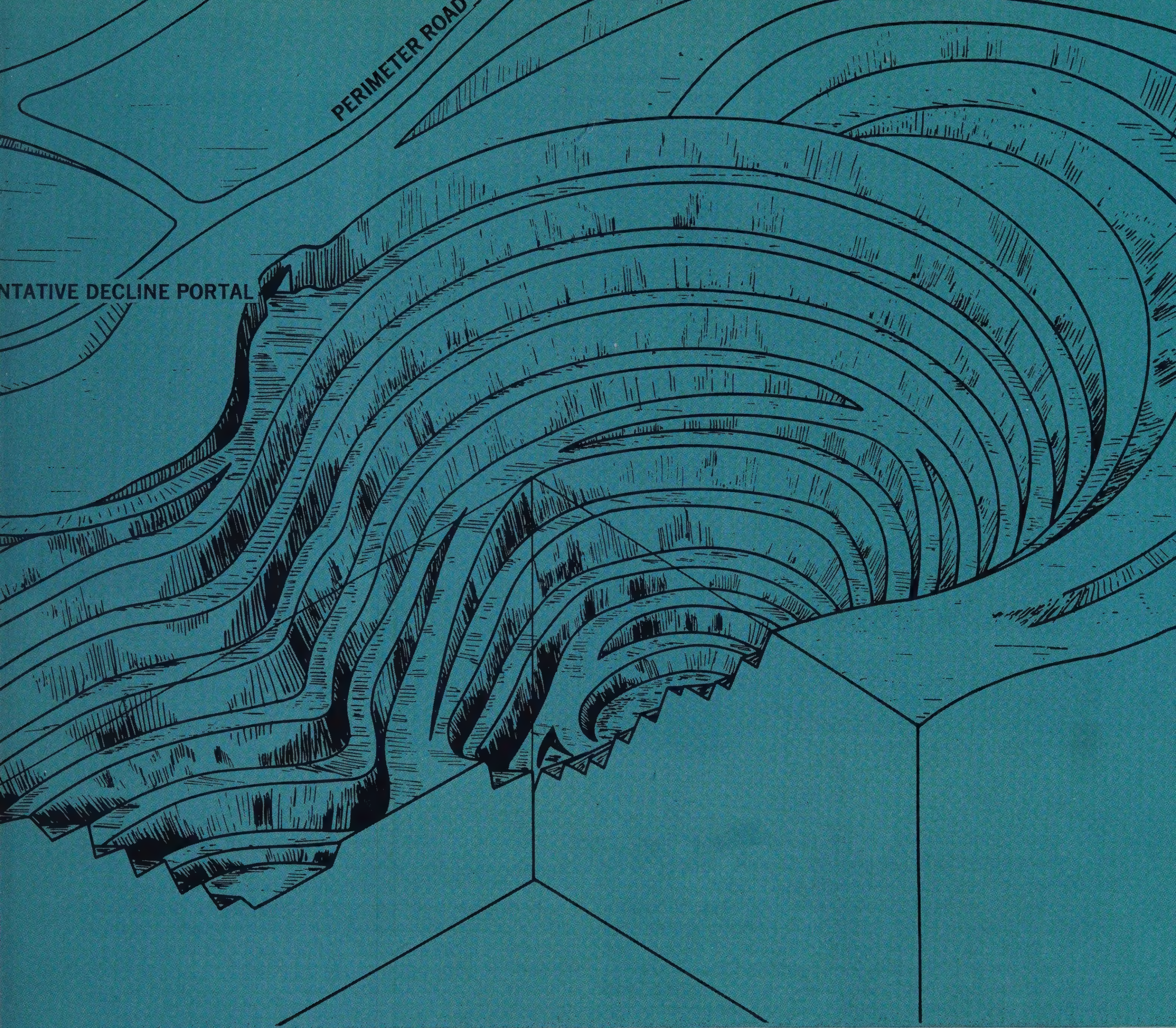
TGS reported that "A" and "C" ore are delivered to the primary crusher at different times and at predetermined fluctuating rates dictated by mill requirements. The amount and variety of ore flow is signaled by an ore haul sheet prepared by the mine's grade control section.

The crusher's minus 6-in. discharge is directed by a 60-in. apron feeder onto a 48-in. belt and conveyed into one of two 5,000-ton bins straddling the pit-to-concentrator track. According to the company, two vibrating feeders on each bin can load a 125-ton ore car in about one minute; six 18-car trains are hauled to the concentrator each day.

The pit is designed for truck haulage on 10% road grades. A bench height of 40 ft was selected – when final pit walls are attained, two benches will be combined into an 80-ft face, and a 40-ft wide safety berm will be left at the bottom of each face. According to TGS, this combination, plus a 60-ft wide road allowance, gives a final wall slope of about 53°. Waste-to-ore extraction ratio will exceed 2-to-1 for the next four years, but is expected to average 1.7-to-1 over the life of the pit.

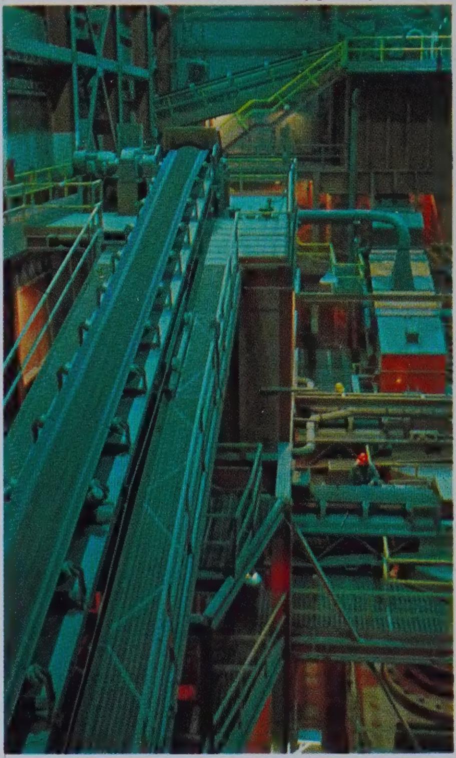


Kidd Creek mine is presently working five benches, the maximum that can be worked simultaneously by the pit's current equipment. If all goes as planned, TGS will eventually mine 19 benches, bottoming the pit in 1980 at 790 ft below the original surface. Plans for the future underground mine, though still in the preliminary stage (so preliminary, that the "tentative headframe" and "tentative decline portal" may, in fact, be positioned elsewhere at the pit), are that shaft sinking will soon get under way, that the sub-pit workings will be turning out about 1.8-million tons of ore by late 1973, that it will account for an increasing proportion of mine production during the late 1970s as the pit phases out, and that, by 1980, it will take over full production.


PERIMETER ROAD
NTATIVE DECLINE PORTAL

HIGHWAY

Central control, the heart of Kidd Creek's concentrator, is a network of complex systems that continuously monitors key plant operations. This TV arrangement keeps a constant check on the ore flow in the concentrator's secondary crushing plant.



At maximum operating efficiency, the secondary crushing plant—incorporated into the mill building for control-maintenance ease—takes primary crusher's −6-in. ore and turns out 800 tph of −⅝-in. product.

As designed, the mill's grinding section has three 3,000-tpd circuits. The validity of the original plans has certainly been substantiated — the section is currently running at just under 10,000 tpd.

The Kidd Creek concentrator is as much a marvel as the orebody it treats. Incorporating the most up-to-date sensing-control systems, the huge plant was designed by Texas Gulf Sulphur, engineered by Parsons-Jurden Corp., and built by The Ralph M. Parsons Construction Co. of Canada Ltd.

Since the concentrator is working round-the-clock all year long in a region where winter temperatures sometimes drop into the −50°F range, TGS felt that its three major operating sections—crushing and grinding, flotation, and concentrate handling—should be under one roof. That roof measures seven acres.

The mill is divided into three circuits: "A", "B", and "C". The first is designed specifically for copper-zinc ore, "C" is specifically for lead-zinc-silver material, and "B", depending on need, can handle either.

The initial plans for the Kidd Creek concentrator called for installing flotation circuits capable of handling 2-million tpy and leaving space in the plant for eventually boosting the capacity to 3-million tpy. However, while putting the final flowsheet into shape, the designers decided to install the third circuit immediately.

The first of the concentrator's three 3,000-tpd sections went on stream in November 1966 and, within days, was at rated capacity.

By February 1967, all three circuits were on stream, producing zinc, copper, and silver-lead concentrates by flotation from finely disseminated ore.

Though designed to treat about 9,000 tpd of the pit's complex ore, the concentrator is now treating closer to 10,000 tpd. It annually produces concentrates containing about 250,000 tons Zn, 12,000 tons Pb, and 50,000 tons Cu. In addition, approximately 13-million oz of silver per year are recovered, primarily in the copper and lead concentrates. Zinc concentrates contain cadmium and small amounts of silver.

Building a pyrite circuit

In the plant's current flotation arrangement, zinc is depressed in the first bank of cells and copper or lead float away and the tailings are then put through zinc rougher and cleaner flotation. Tailings from the rougher cells – currently disposed of in an outdoor pond – will eventually be put through a fourth flotation circuit that will concentrate pyrite.

The reason TGS will go to the expense of incorporating a pyrite circuit into its concentrator is that it believes pyrites will be an important future source of additional sulphur supplies, and therefore wants to stockpile the Kidd Creek material. Also, the company hopes to extract other metals – including tin and some additional silver – as byproducts from the pyrite.

Instrumentation is a key plant item

When the concentrator was first being designed, the TGS staff realized that complexity of the ore, the value of the contained metals, and the need for high recovery dictated a product sampling system more efficient than standard chemical laboratory assaying with its two hour minimum delay in analyzing varying mineral proportions.

Therefore, the company decided to install an X-ray-computer combination for continuously sampling an ore stream's composition. This has become the pride of the Kidd Creek concentrator, and a key factor in maintaining the huge center's high recovery levels.

Specifically, the concentrator's digital computer receives and interprets data gathered from independent X-ray spectrometers. The system provides operators in the plant's central control with information on the relative amount of each of five elements in each of the three process streams. And it can provide a quantitative analysis of the five ele-

As it is now operated, Kidd Creek's flotation arrangement has zinc depressed in the first bank of cells and copper or lead floated away and then the tailings put through zinc rougher and cleaner flotation. The company has set aside space in the mill for a fourth flotation circuit that will concentrate pyrite.

After flotation, concentrates go to their respective thickeners (also housed in the concentrator building) and emerge as a pulp consisting of 65-70% solids. The material then goes to holding tanks and then to filters where the moisture is reduced to about 16-17%. In the drying stage that follows, concentrate moisture is brought down to a final 6%.

ments at a given point in the process within 60 seconds—120 times faster than a chemical laboratory assay.

Equipped with the up-to-the-minute process analyses, the operator can make the necessary flotation reagent adjustments to quickly correct any plant deviations.

Texas Gulf said that central control receives a complete set of assays on copper-zinc every 12 minutes and that the same for lead-zinc comes in every six minutes.

The company feels the on-stream X-ray analysis system has thus far been a success. Its precision has been very high; during calibration, with recirculated samples, the standard deviation was usually zero.

During on-stream operation, the accuracy of the system has also been superior; technicians found that errors here are no greater than for wet assaying.

A main source of the error that did exist in the system was an inability to control pulp density. The Kidd Creek engineers tackled the problem, finally solved it, and now the X-ray analyzing arrangement is being operated under partial automatic control.

Besides handling all X-ray data, the Kidd Creek computer monitors and annunciates all grinding mill and synchronous motor bearing temperatures. It also monitors all tonnages, all crushing and grinding, and types out the information on demand — or does it continuously and automatically every three hours.

The X-ray-computer system is not the only instrumentation guiding the operation of the concentrator. Among the plant's other systems are: gravimetric feeding and weighing of ores, automatic density control, nuclear level-indicating and controlling devices; rotometer-controlled flotation reagents, closed-circuit TV systems for monitoring remote operating stations; and a variety of electronic instruments to provide temperature and pressure data.

After being treated by the plant's flotation section, and after passing through thickeners, final concentrates are pumped to filters. All filter products are conveyed to vertical multiple-hearth dryers. Once dried to about 6% moisture, concentrates go directly to load-out bins adjacent to railroad marshalling yards, and are shipped to smelters.

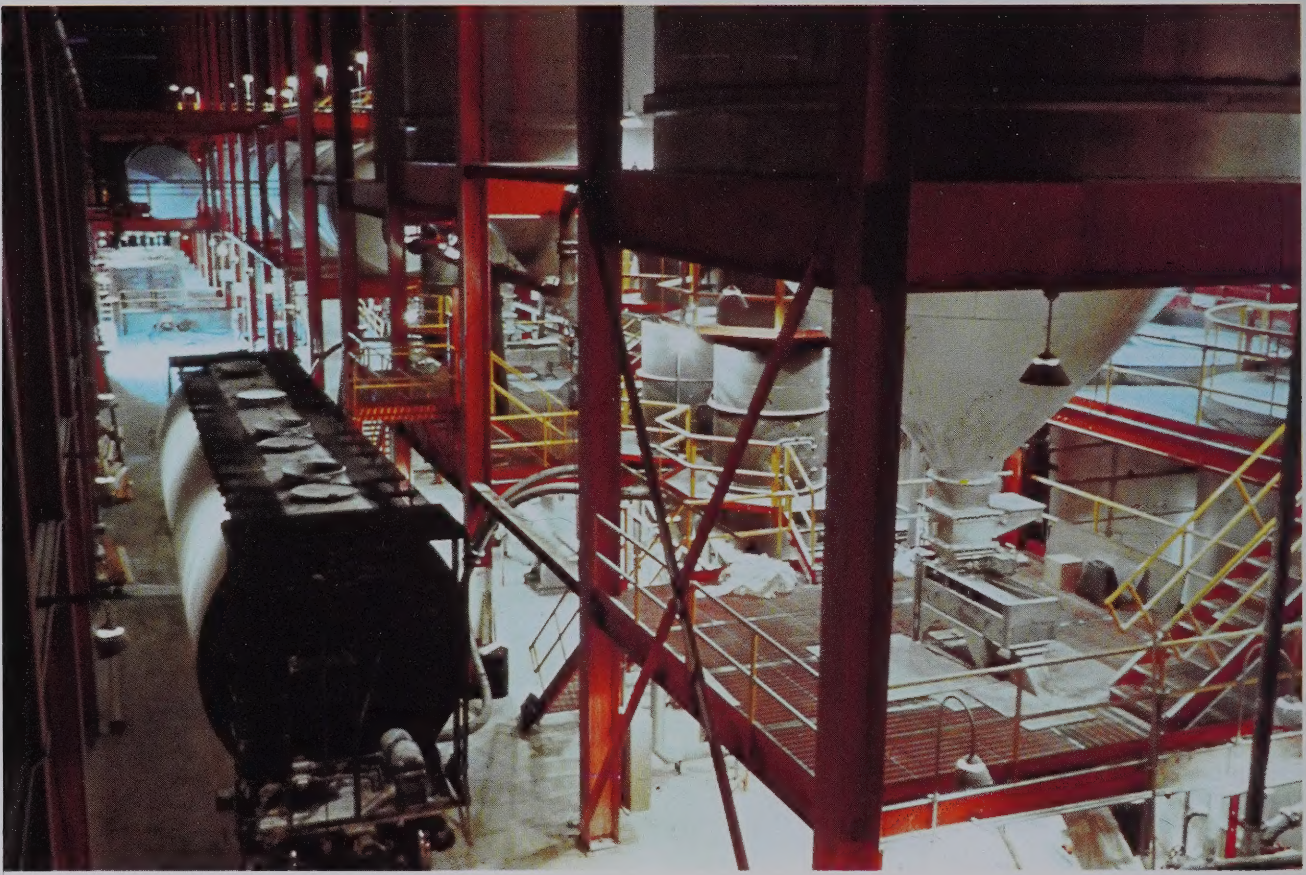
The zinc concentrates are currently being shipped to smelters in Europe, Japan, and the U.S. Copper concentrates are smelted at Noranda and refined at Montreal East —both in Quebec. Also, lead concentrates holding much of the silver are shipped outside Canada for smelting and sale.

In Timmins—and in Ontario generally—this situation has triggered one of the liveliest discussions in years, centering on whether or not the company will build its own smelters for processing the Kidd Creek concentrates.

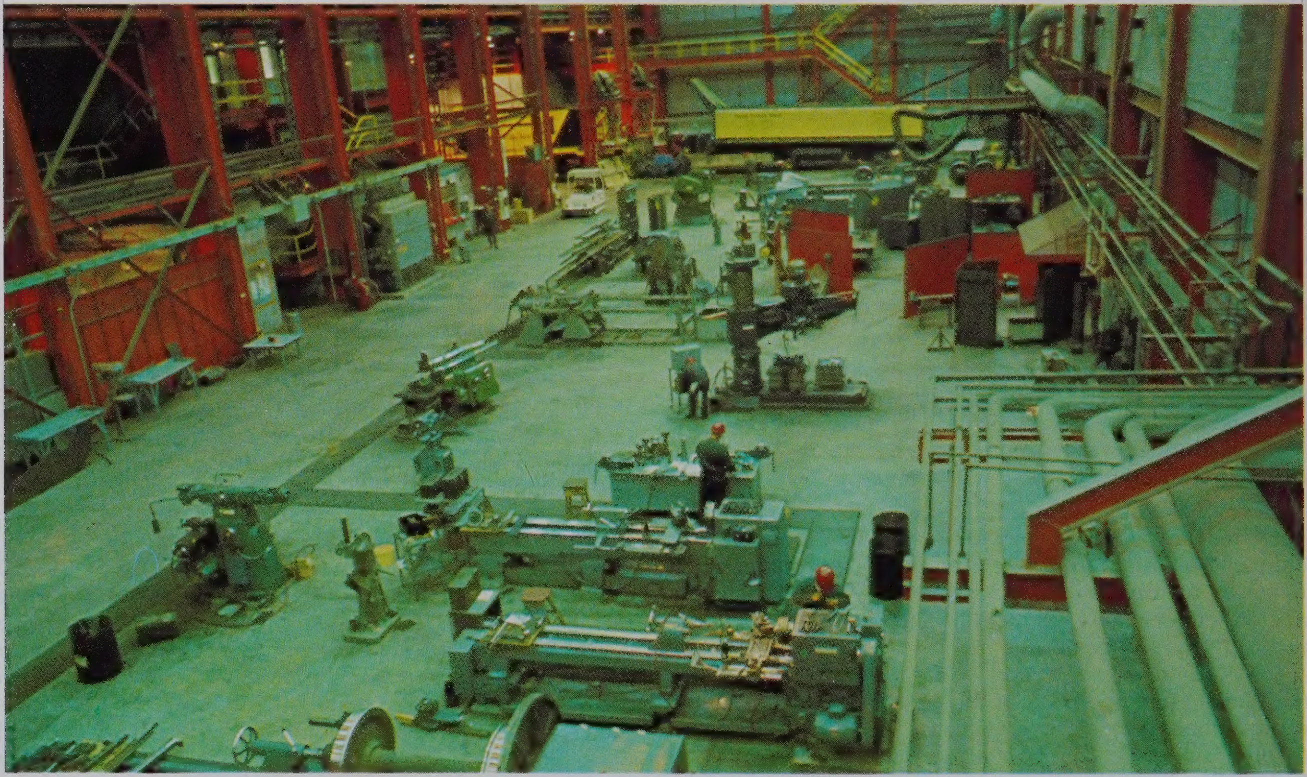
During 1968, Texas Gulf continued a comprehensive feasibility study to decide if smelters should be built; and, if so, where. The company feels the studies will soon be completed and that a decision can soon be announced. Until then, the one thing that seems certain is that if the smelters are built, they will be in Ontario.

An abundance of local talent

While considering the possibility of a smelter, and while actually preparing for the future underground mine, one factor Texas Gulf is not worrying about to any great degree is availability of manpower. In addition to relying heavily on Canadian-manufactured materials for its open pit and concentrator, TGS has drawn almost exclusively from the local work force to fill jobs at Kidd Creek. Though some present pit workers may decide to go underground, most of the future mine staff will be newcomers to TGS. These will either come with experience from other Porcupine mines or, the company confidently predicts, will be trained on the job.



In the plant's reagent unloading area, TGS has laid out efficient facilities for handling and storing dry and liquid materials. All reagents go to holding tanks and then to individual head tanks above central control's rotometer room.



Maintenance section, conveniently located near the mill's secondary crushing and grinding sections, is under control of the Plant Department, but all work is coordinated by the mill. Rail cars (rear) can be easily brought in for repairs.

Success at Timmins rests heavily on ore blending and ultra-modern mill

As a mining study, the fact that the Kidd Creek ore is rich and varied, that the fully-developed pit will be long and narrow, that future underground mining methods will soon have to be worked out, are all very interesting. However, what must stand out as the most fascinating of the deposit's characteristics is that the mineral values are so arranged that, in order to satisfy the concentrator's rather strict demands, the ore must continually be blended. To do this, the mining of various portions of the pit must be carried out according to definite schedules. These daily ore sheets are prepared by the grade control department and issued to the production department. They specify the exact number of truck loads from each area of the pit.

For instance, to achieve a proper blend of "A" ore (copper-zinc), the pit crew must take material from a low-grade copper area, a high-grade copper area, and a zinc area. When drawing "A" ore, each of the three zones must be mucked and hauled concurrently to a specified ratio of truck loads. Since metal content varies greatly within each blast, shovel position must also be specified on the schedule.

Grades of each blast are determined by sampling and assaying the cuttings from each rotary drill hole in the blast. During standard operations, visual estimating by the grade control staff of metal content, backed-up by known assays, is of prime importance.

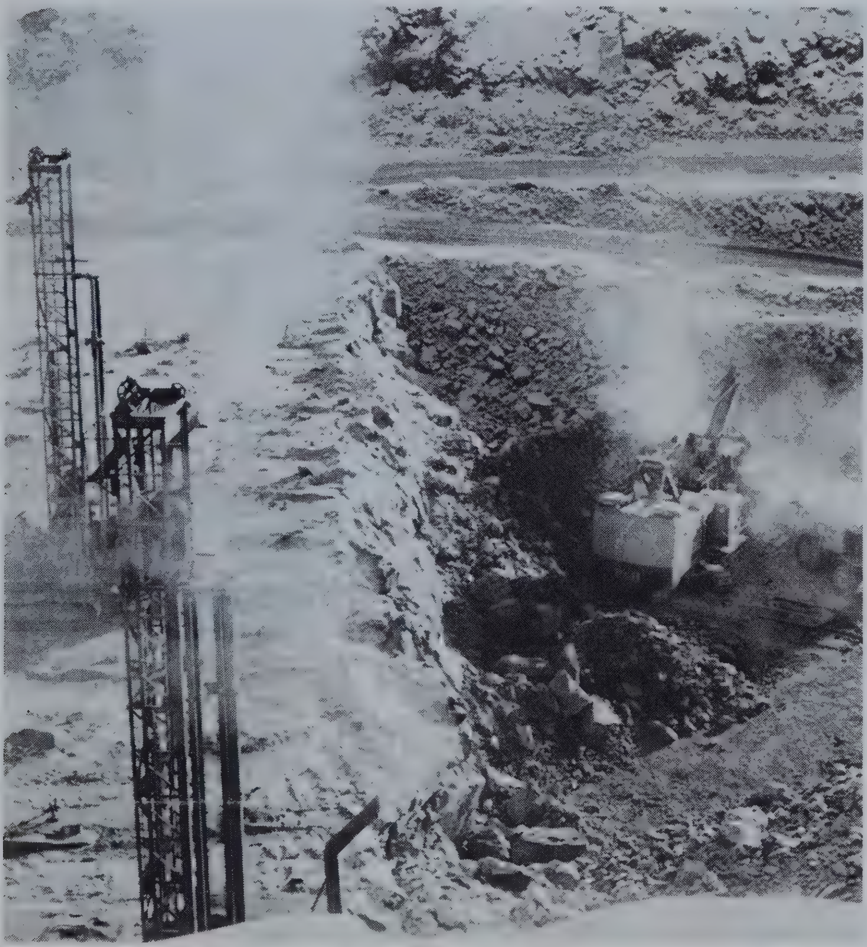
The 10 fundamental rock types that occur in the Kidd Creek pit are resistant enough to require tungsten carbide hard formation rotary drill bits. Bit penetration rates, the mine reported, vary from 18 ft to 35 ft per hour, with the average at about 25 ft per hour.

Drill patterns for the pit's 40-ft high benches are about the same for ore and waste—23 x 23 ft for the 9⅞-in. hole and 21 x 21 ft for the 9-in. hole, with 5 ft of subgrade on each. A pumped aluminized TNT slurry is used to toe load all blastholes with bulk AN/FO, or a low density NCN slurry, making up the column load to a 14-ft to 18-ft unloaded collar.

Powder factors range from 0.5 lb per ton to 0.65 lb per ton, and up until now has averaged 0.60 lb per ton. Current blasting agent consumption is in the ratio of 60:30:10 by weight. An average of 4 to 5⅓ lb of Hi Det or 1 lb of Cor Det primers on twin primacord downlines are used in each hole. Shots are usually sequenced in a wide scallop with 10 to 15-millisecond delays between each

Ever since he graduated as mining engineer from the University of Minnesota in 1941, Texas Gulf vice president Richard D. Mollison has been actively involved in exploration and production. After a series of positions with companies in Canada, the U.S., and South America, he came to TGS in 1947, became exploration manager in 1958, vice president in charge of exploration in '62, and now heads the Metals Division.

Formerly with Canadian Johns-Manville's Asbestos, Quebec, mine as general foreman, George C. Coupland had been assistant mine superintendent at Kidd Creek since 1965; he is now the surface mine superintendent.



Putting down a carefully-figured pattern, the Bucyrus-Erie rotary drills, with tungsten carbide hard-formation bits, average 25 ft per hour.

R. Hugh Clayton, the Metal Div.'s supervisor of special projects, was one of the geophysicists involved in the discovery of the Kidd Creek mine.

Preparing a blast. Pumped aluminized TNT slurry is used to toe load all blastholes, with bulk AN/FO or a low density NCN slurry making up the column load.

Major pit equipment currently in use

Unit	Capacity	Performance
Shovels:		
2 P&H 1600	6 cu yd	550 tph
3 P&H 1400	4 cu yd	400 tph
1 P&H 1055	4 cu yd	400 tph
Loaders:		
1 Dart 600	14 cu yd	450 tph
1 Cat 988	6 cu yd	250 tph
Trucks:		
6 Haulpaks	50 ton	160 tph
14 Euclids	50 ton	160 tph
Drills:		
2 BE 50R	9⅝-in. hole	25 ft per hour
1 BE 45R	9⅝-in. hole	
1 BE 40R	9-in. hole	
Dozers:		
1 Cat D9 Crawler		
4 Cat D8 Crawler		
2 Cat 824 Rubber Tired		

Dropball: 1 Link Belt 45-ton mobile crane with 10,000-lb billet.

Primary Crusher: 1 Allis-Chalmers 54-74 gyratory crusher driven by a 600-hp motor operates 16 hours per day and averages 800 tph with 5½-in. OSS and 1⅜-in. eccentric throw.

Well-equipped garage, welding and electrical shops at the mine provide proper maintenance for all pit machinery.

series of holes. Generally three rows deep, the shots have been averaging 100,000 tons.

The mine staff is currently experimenting with staggered drill patterns (22 x 28 ft and 20 x 25 ft) in an effort to improve pit floors.

All final walls in the pit have been cushion blasted, using large diameter holes on a 10 x 12-ft spacing and a 12 x 15-ft burden. These are loaded with 50-100 lb of slurry in the toe, and 2½ x 16-in. sticks of 60% NBL 209 are strung on the downline to a 10-ft collar. All such holes are completely stemmed.

Texas Gulf said that a project such as Kidd Creek continually presents interesting challenges. One of the most recent, and, it feels, one of the most challenging in the pit, is the series of experiments undertaken to test the effectiveness of pre-shearing.

After being loaded by shovels or front-end units, 50-ton trucks take the carefully-chosen ore to the primary crusher.

At a rate of approximately 1,900 tons per trip, 18-car trains haul the crushed ore 17 miles to the concentrator.

The 2½-in. pre-shear holes on 2-ft centers are loaded at 0.18 lb per ft of hole by spacing 1 x 8-in. Gelrex 2 cartridges about 8 in. apart down the hole with one stick of 1½ x 16-in. in the bottom.

The company said holes are fired simultaneously and well in advance of the two- or three-row production blast. Engineers soon found that a buffer row of 2¾-in. or 3-in. holes on a 5 x 5-ft pattern, and loaded with 0.4 lb per ton, was needed between the pre-shear and the production blast because the final wall was still being damaged by the larger blast.

The early enthusiasm Texas Gulf had regarding pre-shearing has been supported by favorable operating results—it will most likely become standard operating procedure.

Once blasted, pit ore is conventionally shovelled into trucks and hauled to the primary crusher.

A double-bladed slusher bucket on the 45-ton crane is used to scale final walls. A "Giraffe" with a 90-ft boom is currently being studied to ease the final scaling that now must be done by hand.

A piece of pit equipment that seems to have worked well for TGS is a maneuverable KW-Dart-Sicard D-600 front-end loader. It was purchased for the following services:

1) blend ore from two or more shots and be able to eliminate three or four shovel moves per day:

2) load out low-profile, loosely piled ore or waste—particularly after a new blast;

3) load low-profile pile from breakerball operation;

4) Load crushed ore from stockpile into rail cars.

The versatile loader moves rapidly around the pit, and has effectively done the various tasks expected of it.

Before a blast, mine surveyors pinpoint holes to be drilled; after a blast, they return to check floor, walls and crest.

Service and maintenance—a gigantic task

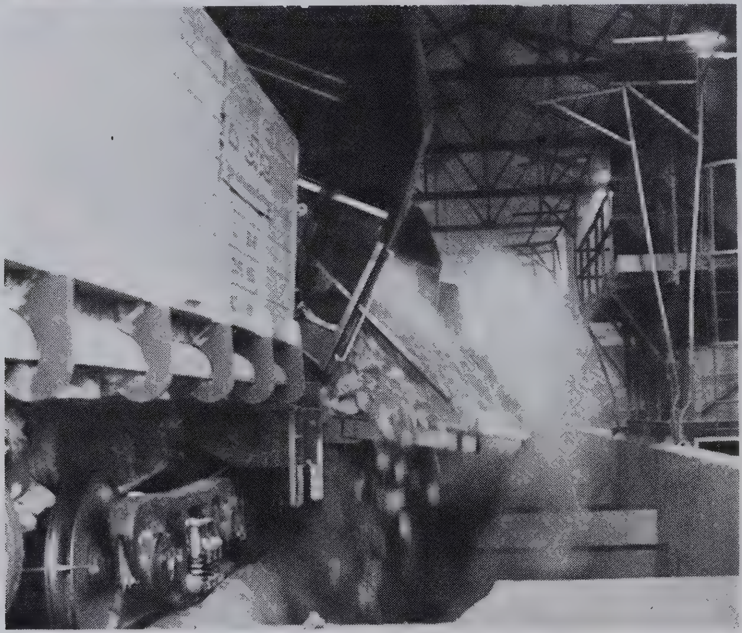
To keep the Kidd Creek equipment in first-class order, especially during the severe Canadian winter, TGS has a collection of shops, an elaborate set of rigs, motors, and machines, and a staff of competent specialists. In charge of all this is maintenance superintendent Gerard F. O'Halloran.

Goal of the company's planned preventive maintenance control system is to have the maximum amount of equipment available, with little or no unscheduled down time for any piece.

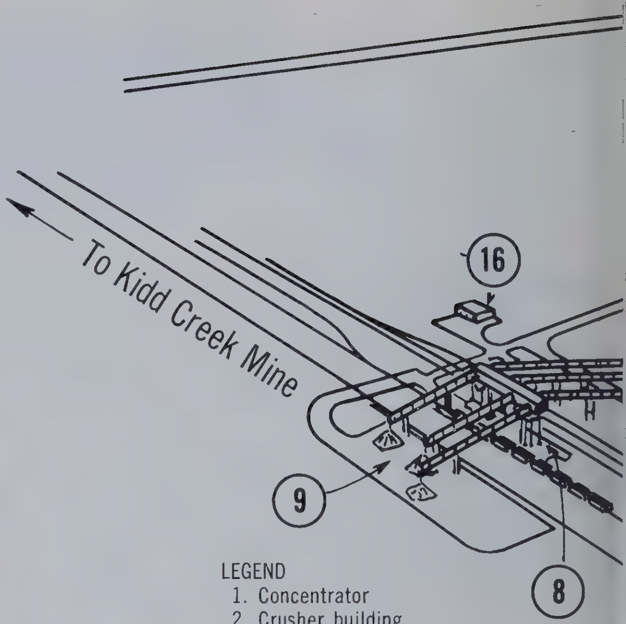
To try attaining this, TGS has set up a well-organized department to carry out well-organized programs.

A co-ordinating group does all record keeping, timekeeping, auditing, planning and follow-up of work orders. As a sideline, this section also handles ultrasonic testing for shafting and pipe and does tests on bearings.

Traffic superintendent David G. Baskin spent 15 years with Canadian Pacific Ry before joining TGS at Okotoks, Alberta, in 1959. After experience there and at another TGS Alberta operation, he came to Kidd Creek in 1966.



At the concentrator, the 110-ton capacity ore cars are side-dumped either manually or automatically.



LEGEND
1. Concentrator
2. Crusher building
3. Transfer tower
4. Railroad operations office
5. Warehouse
6. Train snow shed
7. Ore unloading station
8. Concentrate load-out and weigh stations
9. Concentrate storage
10. Gate house
11. Employee parking area
12. Gas metering station
13. Water tank
14. Electric substation
15. RR repair shop
16. Sewage treatment plant
17. Reagent mixing section
18. Plant office building
19. Dryer building

According to O'Halloran, maintenance department work under the control system breaks down into: inspection and servicing; new work, including construction, repairs; and job training.

To carry out inspection and servicing, the maintenance department established a coding for 11 variations which serve as a skeleton upon which to base the writeup (maintenance profile) for large units or areas.

The writeup spells out when and how inspection and servicing are to be done, and how much time should be spent doing it. As soon as a writeup on a piece of equipment is completed, the co-ordinator assumes responsibility for work orders and records. He also time-studies the recurring main inspection and servicing tasks.

Repair work is planned in advance, and, on major items, is written up on a critical path pattern, trying as much as possible to do the necessary work when it will have the least effect on production.

To provide maintenance services at the pit, the company operates a well-equipped garage, welding shop and electrical shop; at the concentrator are a machine shop, welding shop, locomotive repair shop, electrical shop, carpenter shop, and garage.

When carrying out maintenance, O'Halloran can put any of the following items to work:

1) A Frames on tandem trucks (two)
2) Hydraulic loaders on 3-ton trucks (two)
3) 3-ton Dump trucks (three)
4) Tandem dump trucks (two)
5) 409 Auston Western cranes, 15,000-lb capacity (two)
6) 5-ton lubrication truck (one)
7) 30-ton crane (one)
8) 45-ton crane (one)
9) Allis-Chalmers TL 14-D front-end loaders (two)
10) Hopto Loaders backhoe (one)
11) Allis-Chalmers H-D-6E dozer (one)

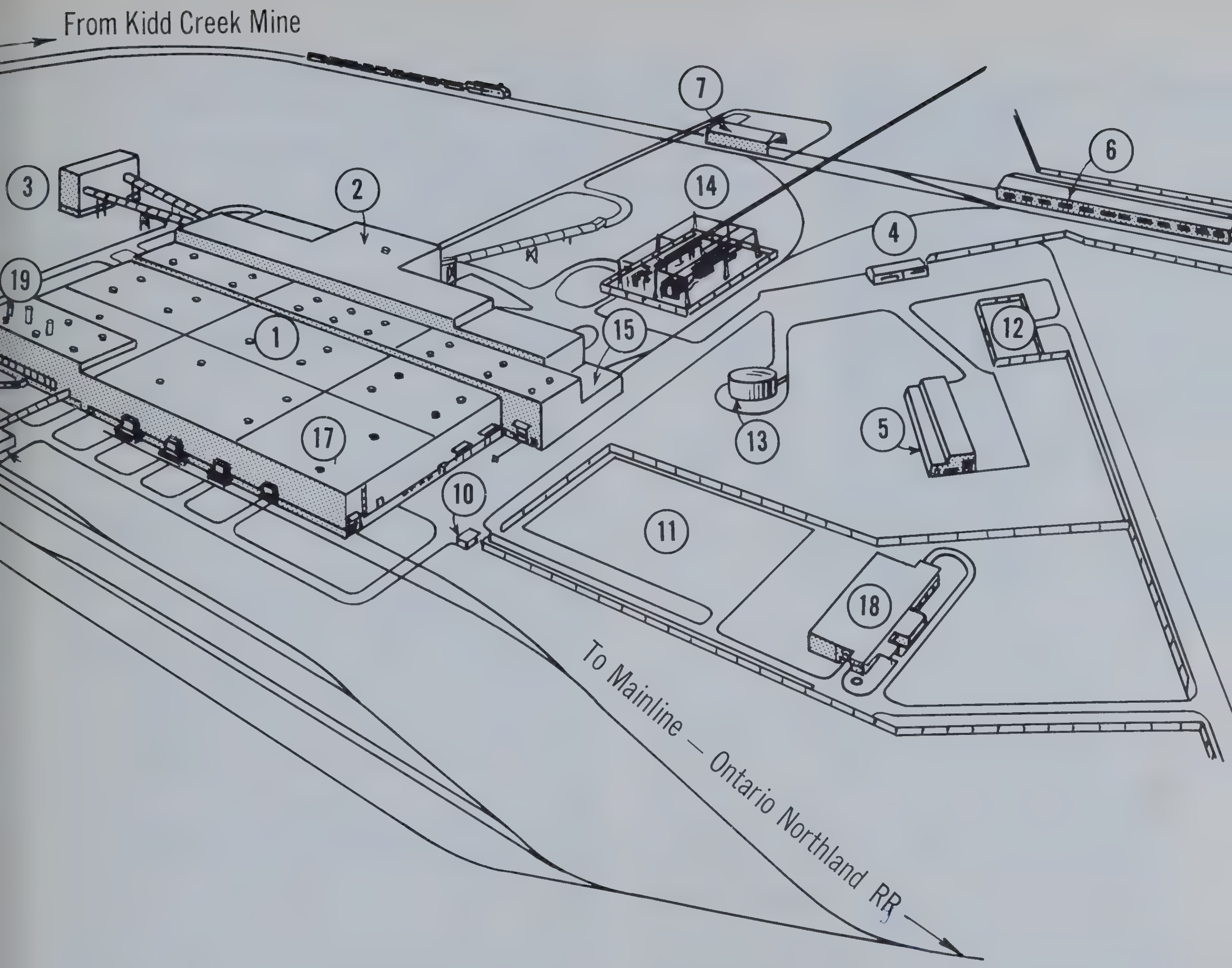
From mine to plant—and back

The rail line from Kidd Creek's pit to the concentrator runs over 17 miles of muskeg. Before the rails could be put down, the muskeg and clay had to be stripped away and backfilled with granular fill.

Under the direction of Dave Baskin, traffic superintendent, the ore trains operate on two shifts seven days a week and pull about 1,900 tons of ore away from the mine on every trip.

Supplying the power for the ore haul system are two 1,000-hp diesel-electric road-switch locomotives built by Montreal Locomotive Works. On an average trip they pull 18 of the side dump ore cars.

Made by National Steel Car Corp. Ltd., the cars have a splitter plate at the far end in line with the dump side. These plates make it possible to have continuous or semi-continuous loading of the cars. The cars are fitted with flapper valve extension arms, which are activated by fixed stanchions in the dump pits.



From first core to full production . . . Kidd Creek's successful timetable

The company had found a rich deposit—it was now up to its able metallurgists to map out the most practical recovery schemes. What resulted was a fastpaced campaign to unravel the tangle of the Kidd Creek orebody.

Spearheaded by Robert J. C. Tait, chief metallurgist, and P. Ray Clarke, formerly mill superintendent and now manager of operations, Texas Gulf's two-year march to production included working with various research teams scattered throughout Canada and the U. S. Here's how it was done:

April-Nov. 1964—Limited metallurgical testing done on isolated cores by several companies, including Galigher, Denver, and Lakefield Research

Aug. 1964-Mar. '65—Test program at Lakefield by Tait and Clarke. By March 1965, metallurgical bench work completed and good results obtained on drill core mixtures of both ore types. Decision made to mine selectively; enough information now available to start mill design.

April 1965—Bench tests continued at Lakefield.

Mar.-Aug. 1965—Ray Clarke worked with Parsons-Jurden in New York on design of concentrator, equipment selection, etc. J. Frank Henderson, TGS assistant manager of research, New York, served as liaison between company and Parsons-Jurden during design of the mill, and during construction and start-up.

May-July 1965—Bob Tait carried out pilot plant tests at Lakefield (24tpd), and assisted in the selection of milling equipment.

May-June 1965—Tait pilot tests at Ottawa (24tpd) with Stephen Y. Mostowy.

Sept.-Nov. 1965—Tait pilot testing at Lakefield (24tpd) with Michael Amsden.

Oct. 1965-Oct. '66—Kam Kotia pilot program; 1,100 tpd, 10 days per month carried out by Tait, Mostowy, and mill staff; on Cu-Zn ore—"A" ore.

Apr. 1966-Dec. '66—Broulan Reef piloting done by Tait, Amsden, and the mill staff; 200-400tpd continuously on Pb-Zn ore—"C" ore.

Aug. '65-Nov. '66—Ray Clarke supervised process installation in conjuction with construction supervised by Alan G. Perry, superintendent of engineering.

Nov. 16, 1966—"A" circuit started.

Jan. 13, 1967—"B" circuit started.

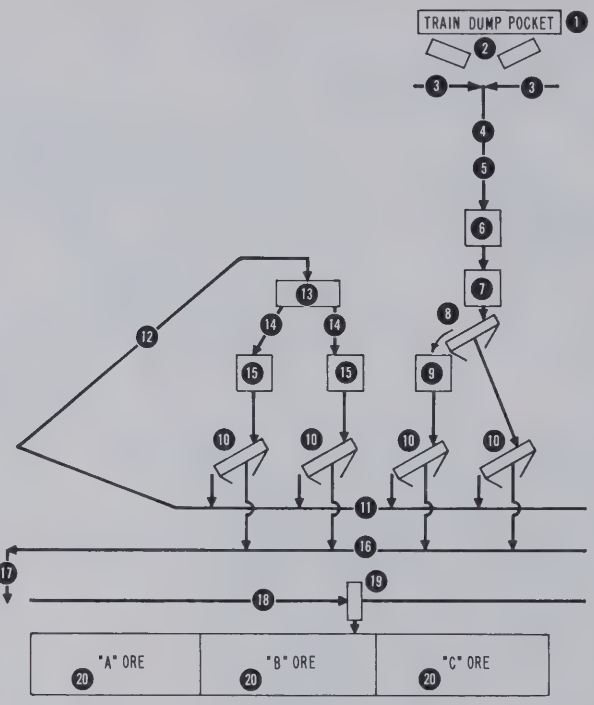
Feb. 14, 1967—"C" circuit on stream on half tonnage—mill head missing.

Mar. 18, 1967—"C" circuit on full tonnage.

1967—Just over 3-million tons—original target. Metallurgy proved sound.

1968—During the first full year of operations, more than 3.6-million tons of ore were mined and milled, producing about 562,400 tons of 52% zinc concentrates, 205,400 tons of 23% copper concentrates, 96,000 tons of lead concentrates, with the above concentrates containing 13.396-million oz of silver.

What's ahead—Pilot and lab testing are now going on to improve the concentrator's present recovery, and to recover additional products such as tin and pyrites. Also, the cyanide process for extracting silver from the pyrite and tailings is being reviewed.



Kidd Creek concentrator–crushing plant

Legend

1. Train dump pocket, live load approximately 2,400 tons.
2. Six Hewitt-Robins mechanically vibrated feeders, 48 x 96 in., 10 hp.
3. Two horizontal belt conveyors, 48 in., 15 hp.*
4. One inclined belt conveyor, 48 in., 250 hp, centrifugal clutch start.
5. One Merrick Weightometer.
6. 50-ton surge bin.
7. One Hewitt-Robins mechanically vibrated feeder, 60 x 144 in., 30 hp.
8. One W. S. Tyler Co. Ty-Rock vibrating grizzly, cast manganese tapered rod deck, 1½-in. openings, 25 hp, 6 x 14 ft.
9. One Canadian Allis-Chalmers secondary Hydrocone crusher, 350 hp.
10. Four W. S. Tyler Co. Ty-Rock vibrating screens, 6 x 14 ft, rod deck, 1⅛-in. set. ⅝-in. openings, 25 hp.
11. One inclined belt conveyor, 36 in., 75 hp.
12. One inclined belt conveyor, 36 in., 75 hp.
13. Re-cycle surge bin.
14. Two horizontal belt conveyors, 36 in., 5 hp, variable speed drive.
15. Two Canadian Allis-Chalmers tertiary Hydrocone crushers, 350 hp, ½-in. set.
16. One inclined belt conveyor, 36 in., 125 hp.
17. One horizontal belt conveyor, 36 in., 10 hp.
18. One inclined (tripper) conveyor, 36 in., 10 hp.
19. One motor-propelled Stephen-Adamson tripper.
20. Three fine ore bins, live load approximately 7,500 tons "A" ore. 9,500 tons "C" ore.

* All components of the Kidd Creek conveyers (belting, idlers, pulleys, shafts, pillow blocks and take-ups) were purchased on a lot basis – all pulleys from one supplier, all belting from another source, etc. Here, as outlined by Parsons-Jurden, are the main items in the various systems:
Belting—supplied by BTR Industries Canada Ltd. Has warp and weft of nylon doubled with cotton and with a rubber skim coating between plies. Breaker strips are Transcord nylon, wrap-around construction. In all cases, ply-to-ply adhesion is minimum 20 lb per in. and ply-to-cover is 15 lb per in.
Idlers—Stephens-Adamson three roll 35° troughing idlers, arranged for three shot lubrication from one side. For 48-in. belts, the rolls are 7-in. dia; for 36-in. belt, troughing idlers have 6-in. dia rolls; for 24-in. belts, both 6 in. and 5 in. Return idlers are spool type, 6-in. dia, with 2-in. tires and ¾-in. shafts.
Pulleys and shafts—are all made by Rex Chainbelt. Pulleys are crown faced with ⅜-in. herringbone grooved lagging on all head pulleys; all others have ⅜-in. rubber plain lagging.
Pillowblocks and take-ups—are all supplied by Canadian SKF.

The following brief outline of certain aspects of the Kidd Creek concentrator has been based on operating notes compiled by manager Ray Clarke while he was still mill superintendent. They describe actual operating conditions, not the hypothetical levels derived in laboratories, and, as such, give an interesting profile of the concentrator's daily performance.

After the concentrator went on stream, TGS engineers, for a variety of reasons, made various modifications throughout the complex to improve operating efficiency. This is usual practice in an installation of Kidd Creek's size and complexity. According to the company, modifications to date have been carried out rather smoothly.

When a loaded ore train arrives at the concentrator, cars dump into a 2,000-ton bin. To overcome problems of freezing, TGS modified the bin to "hopper bottom", and added doors to the dump shed's load-in. It feels that these changes have greatly helped train dumping.

To further improve operations at the unloading station, Kidd Creek engineers installed gamma gages at the bin's six chutes, shutting off the six vibrating feeders while there are still several feet of ore in the chute. This "ore plug" prevents feeder damage during car dumping and also eliminates the down-casting of dust, an initial headache.

Closely-monitored crushing plant

The secondary crushing plant was designed to produce 800 tph of −⅝-in. product from the gyratory's −6 in. material. Clarke said that while the secondary units will do this, they will do so only under maximum operating efficiency.

As originally designed, dust control in this part of the concentrator was quite satisfactory, except for the method of disposal. The original scheme—to "pug" the dust with water and drop it on the final product belt—was replaced by one which has the slurried dust pumped over to one of the grinding circuits.

The original dust control scheme included passing wetted dust to the final product belt, but pumping slurried dust over to a grinding circuit has proven to be much better, Clarke said. The amount of dust is well below the legal requirement and will be better still as a result of improvements such as a powerful vacuum cleaning system.

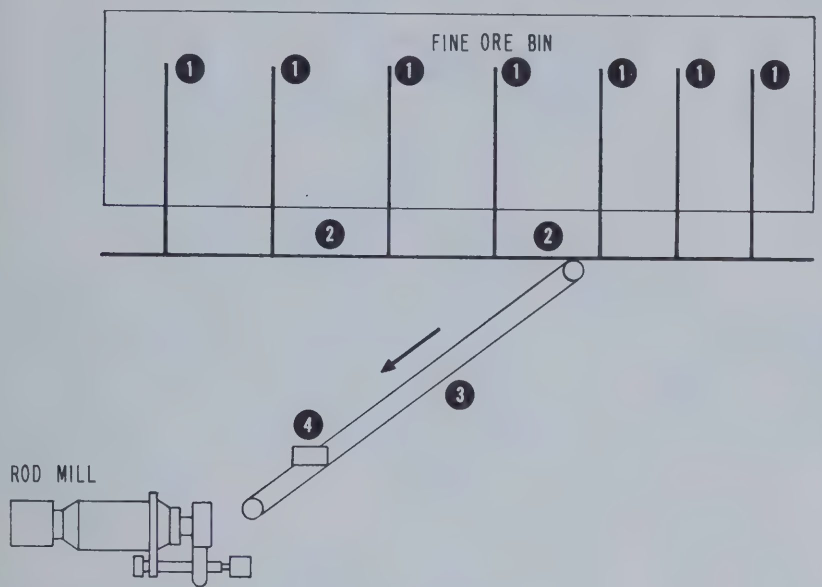
The crusher's materials handling network has worked well from the very beginning. However, some engineers initially questioned the validity of the belt transfer tower which raises the crushing plant's product to the top of the fine ore bins. Texas Gulf feels that the tower—necessary when the crushing plant is built right next to the mill's fine ore bins—has proved to be an extremely neat and easy-to-operate plant feature.

Each of Kidd Creek's fine ore bins has an 8,000-ton average live load capacity. Though not as large as the operators had hoped, they are large enough, when full, to hold two days ore supply for each circuit.

According to Ray Clarke, the bedding of the bins, with the tripper in an east-west direction, and with each bin having seven discharge belts in a north-south direction, has made it possible to achieve the design criteria of maximum ore blending.

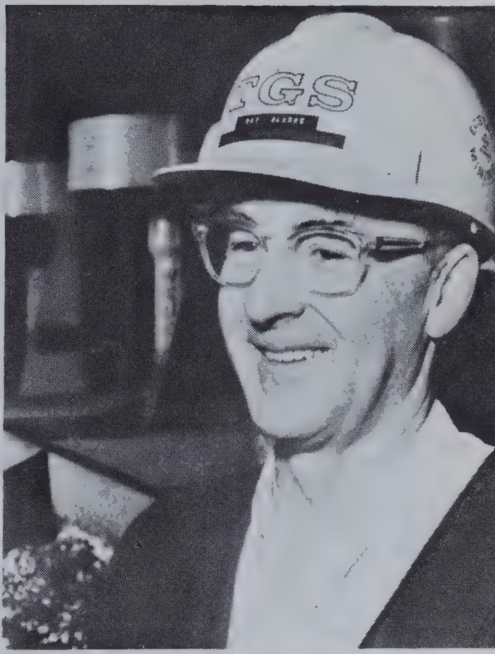
The seven feeders on each bin are controlled automatically by a Model E Merrick Weightometer monitored from central control, where the desired tonnage is set. The control is carried out through a magnetic clutch which speeds up or slows down all feeders equally on demand;

Kidd Creek concentrator—rod mill feed system



Legend

1. Seven (per division) slot feeders discharging on seven 24-in. horizontal conveyors; variable speed 5-hp motors.
2. Two horizontal belt conveyors, 7.5 hp, 24 in.
3. One inclined belt conveyor, 7.5 hp, 2 in.
4. Merrick Weightometer.



Ray Clarke helped map out the entire Kidd Creek concentrator, guided its flowsheet design, participated in its construction, and, once it was in production, was mill superintendent before becoming manager of operations.

if one of the seven feeders is not operating, the other six will speed up to feed the desired tonnage to the rod mill.

Central control, which regulates secondary crushing operations, is actually 150 ft from the crushing plant. The control's crusher panel clearly shows all of that section's pertinent components and operations; an operator in central control can actually oversee operations more effectively than if he were in the crushing section.

The regulating panel, which has stop-start buttons for every piece of crushing plant equipment, permits operators in central control to take immediate action if something goes wrong. One form of that action could be to tell several operators who "police" the crushing circuit to go to trouble spots indicated on the control board.

Certain signals affecting the smooth functioning of the crushing plant are responded to at the concentrator; some are sent to the mine. A typical trainload of ore from the pit is mainly all "A" ore (copper-zinc), or all "C" (lead-zinc). Whatever seems to be lacking in either the unloading bin or in any fine ore bin can be called immediately.

Well-planned, three-circuit grinding section

The Kidd Creek grinding circuit was designed in three 3,000-ton sections and currently is running at just under 10,000 tpd.

Equipment in the grinding circuit (see flowsheet) is basically Allis-Chalmers mills, Allis-Chalmers SRL-V pumps and Krebs cyclones. All pumps and pump boxes are in duplicate. The company is justifiably proud about the mill pumps—they were originally designed by the TGS staff, and though the speeds of some have been raised, no pump has so far been replaced. Chutes and piping, however, were not entirely satisfactory; TGS has already revamped the chutes and will soon revise the piping and valving.

The grinding flow plan consists of primary, secondary, and regrind circuits. The primary contains a 10.5-ft x 16-ft rod mill with 4-in. rods taking the fine ore bin feed and reducing it to about 10-14 mesh. Rod mill discharge goes into the primary mill discharge pump box and is sent to 15-in cyclones.

Cyclone underflow goes to a 12 x 18-ft primary ball mill working in closed circuit with the 15-in. cyclones and having $1\frac{13}{16}$-in. Burlington forged steel balls.

The 60% – 325 mesh cyclone overflow goes to the secondary mill discharge pump box when treating "C" ore; with "A" ore, it is pumped over to the concentrator's flotation section where a first primary float is made to recover copper mineral liberated at this coarse grind. Texas Gulf said about 60% of the recoverable copper is floated here. Tailings from the primary copper flotation are then pumped to the secondary mill discharge pump. Measuring 12 x 18 ft, and equipped with 1½-in. Burlington forged steel balls, the secondary mill is in closed circuit with 10-in. cyclones. Feed to the mill is the cyclone underflow; the overflow—about 80% – 325 mesh— is the feed to the main flotation circuits of both "A" and "C" ores.

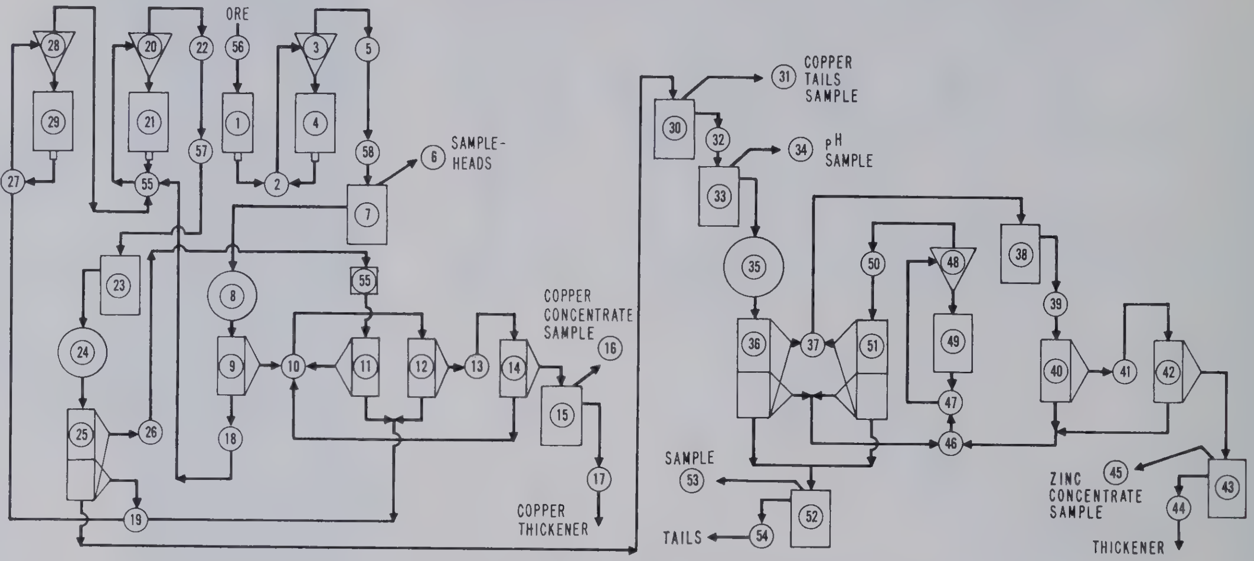
Each circuit has two regrind mills—8 x 12-ft units with 1-in. forged steel balls and in closed circuit with 6-in. cyclones. Cyclone overflow is about 95% – 325 mesh.

Regrinding of copper middlings is necessary for further liberation of chalcopyrite-pyrite and chalcopyrite-sphalerite middlings. Regrinding of zinc middlings is necessary for liberation of sphalerite-pyrite middling and lead regrind is necessary for liberating the galena-silver-pyrite middling.

The grinding circuit runs on a constant maximum tonnage maintained by a Merrick Model E Weightometer, which Clarke claims has worked very well. Rod mill density is maintained by an ore-water ratio control; density control is automated by using Accuray gamma gages.

Rod mill liners are a mixture of Ni-hard and manganese. All of the primary mills have Ni-hard liners, two secondary mills have rubber liners and one Ni-hard, and two regrind mills have rubber and four Ni-hard. The company said, however, that the concentrator has not been operating long enough to make any comparisons between rubber

Kidd Creek concentrator—"A" and "B" grinding and flotation



Legend

1. Canadian Allis-Chalmers 10.5-ft dia x 16-ft rod mill.
2. Cyclone feed pump, 12 x 10 in.
3. Five Krebs D15B hydrocyclones (primary cyclones).
4. Canadian Allis-Chalmers 12-ft dia x 18-ft ball mill.
5. Conditioner feed pumps, 10 x 8 in.
6. Galigher Vacseal 1½-in. vertical pump.
7. Conditioner, 8-ft dia x 8-ft high.
8. Denver 6-ft dia distributor.
9. Wemco Fagergren flotation cells, 66 x 60 x 29 in.—three banks of five cells each.
10. 5 x 5-in. pumps.
11. Denver Sub-A #24 flotation cells—two banks of five cells each.
12. Denver Sub-A #24 flotation cells—six cells.
13. 5 x 5-in. pumps.
14. Denver Sub-A #24 flotation cells—four cells.
15. Sample agitator, 8-ft dia x 8-ft high.
16. Galigher Vacseal 2½-in. vertical pump.
17. 5 x 5-in. pumps.
18. 10 x 8-in. pumps.
19. 5 x 5-in. pumps.
20. Fifteen Krebs D10B hydrocyclones (secondary cyclones).
21. Canadian Allis-Chalmers 12-ft dia x 18-ft ball mill.
22. Conditioner, 12-ft dia x 12-ft high.
23. 10 x 8-in. pumps.
24. Denver 6-ft dia distributor.
25. Fagergren flotation cells, 60 x 60 x 29 in.—"A" division: three banks of 17 cells each; "B": five banks of 14 cells each.
26. 10 x 8-in. pumps.
27. 10 x 8-in. pumps.
28. Fifteen Krebs D6B-12° hydrocyclones (regrind cyclones).
29. Canadian Allis-Chalmers 8-ft dia x 12-ft regrind ball mill.
30. Conditioner, 12-ft dia x 12-ft high.
31. Galigher Vacseal 2½-in. vertical pump.
32. 10 x 8-in. pumps.
33. Conditioner, 12-ft dia x 12-ft high.
34. Galigher Vacseal 1½-in. vertical pump.
35. Denver zinc rougher distributor, 8-ft dia.
36. Fagergren flotation cells, 66 x 60 x 29 in.—five banks of 17 cells each.
37. 10 x 8-in. pumps.
38. Conditioner, 8-ft dia x 8-ft high.
39. Denver 5-ft dia distributor.
40. Fagergren flotation cells, 66 x 60 x 29 in.—two banks of five cells each.
41. 6 x 6-in. pumps.
42. Twelve 60 x 60 x 29-in. Fagergren cells.
43. Sample agitator, 8-ft dia x 8-ft high.
44. 10 x 8-in. pumps.
45. Galigher Vacseal 2½-in. vertical pump.
46. 10 x 8-in. pumps.
47. 10 x 8-in. pumps.
48. Fifteen Krebs D6B-12° hydrocyclones (regrind cyclones).
49. Canadian Allis-Chalmer 8-ft dia x 12-ft regrind ball mill.
50. 10 x 8-in. pumps.
51. Fagergren flotation cells, 66 x 60 x 29-in.—five banks of 17 cells each.
52. Conditioner, 12-ft dia x 12-ft high.
53. Galigher Vacseal 2½-in. vertical pump.
54. 10 x 8-in. pumps.
55. Conditioner, 8-ft dia x 8-ft high.
56. Merrick Weightometer.
57. Accuray gamma gage.
58. Accuray gamma gage.

Note: 1. All pumps, unless specified, were supplied by Canadian Allis-Chalmers.
2. All agitators and conditioners are Lightnin Mixers.

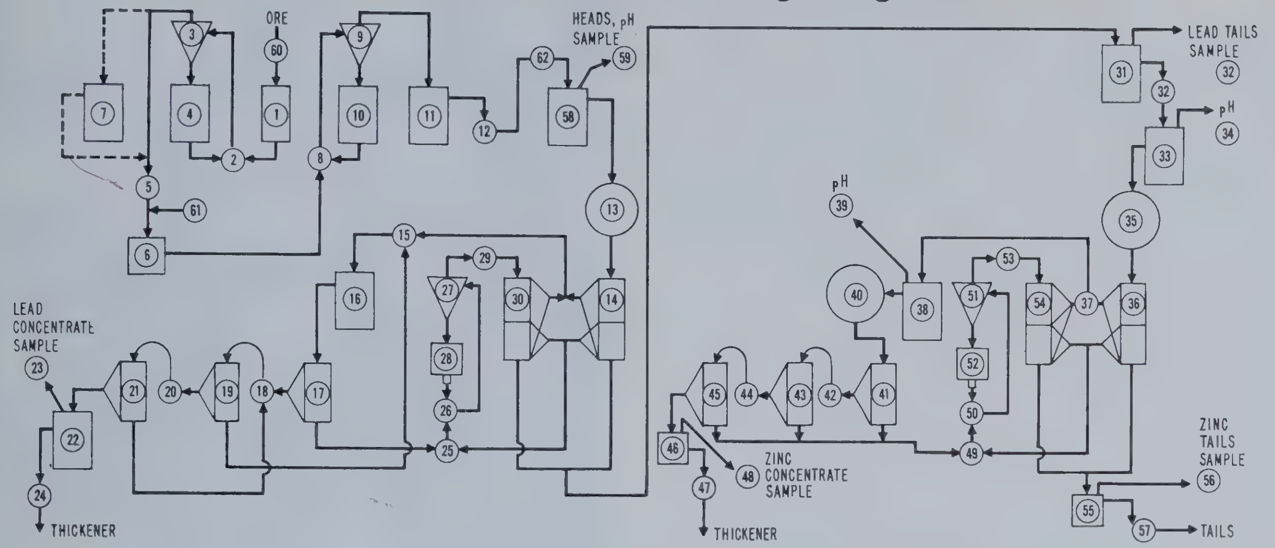
liner wear and steel liner wear.

According to Clarke, steel consumption is about 4 lb per ton of ore ground, and is accounted for as follows: rod milling, about 1 lb per ton; primary ball milling, 1.2 lb per ton; secondary ball milling, 1.4 lb per ton; and regrinding, 0.4 lb per ton. This consumption, the company reported, is the result of a combination of hard ore and fine grind.

Treating the copper-zinc ("A" ore). On the average, "A" ore is low pyritic, but slightly harder to grind than the lead-zinc ore. A typical head with this ore is 2.3% Cu, 8.0% Zn, and 1.0 oz Ag per ton.

Mineralogically, the copper-zinc ore covers a wide range of mineral association, but on the whole can be classed as medium-difficult. A grind of 80% —325 mesh is required to get comparatively complete (90%) liberation of chalcopyrite from pyrite, sphalerite and gangue, although generally about 60% of the copper is fairly well liberated at a grind of 55-60% —325 mesh. The remaining 10% is intimately locked with pyrite and sphalerite and regrinding to 92-95% —325 mesh liberates an additional 5-6%. Clarke said the sphalerite is quite similar in association, but here again regrinding is required to treat sphalerite-pyrite interlocking. Even with this, about 10% of the sphalerite is in a middling form.

According to Clarke, copper flotation consists of a "coarse" primary float, a "fine" rougher float, and three stages of cleaning for the copper to produce the final concentrate. In the copper circuit, reground middlings are recycled to the head of the "fine" rougher cells. The zinc is roughed once and cleaned twice, but the reground middlings from the bottom end of the roughers and cleaner tails, Kidd Creek concentrator—"C" and "B" grinding and flotation



Legend

1. Canadian Allis-Chalmer 10.5-ft dia x 16-ft rod mill.
2. 12 x 10-in. pumps.
3. Five Krebs D15B hydrocyclones (primary cyclones).
4. Canadian Allis-Chalmers 12-ft dia x 18-ft ball mill.
5. 10 x 8-in. pumps.
6. Conditioner, 8-ft dia x 8-ft high.
7. Sparging agitator, 12-ft dia x 12-ft high.
8. 12 x 10-in. pumps.
9. Krebs D10B hydrocyclones (secondary cyclones).
10. Canadian Allis-Chalmers 12-ft dia x 18-ft ball mill.
11. Sparging agitator, 12-ft dia x 12-ft high.
12. 10 x 8-in. pumps.
13. Denver 6-ft dia distributor.
14. Wemco Fagergren flotation cells, 66 x 60 x 29-in.—four banks of 14 cells each.
15. 10 x 8-in. pumps.
16. Conditioner, 8-ft dia x 8-ft high.
17. Five Wemco Fagergren flotation cells, 66 x 60 x 29 in.
18. 5 x 5-in. pumps.
19. Wemco Fagergren flotation cells, 66 x 60 x 29 in.
20. 5 x 5-in. pumps.
21. Wemco Fagergren flotation cells, 66 x 60 x 29 in.
22. Sample agitator, 8-ft dia x 8-ft high.
23. Galigher Vacseal 2½-in. vertical pump.
24. 5 x 5-in. pumps.
25. 5 x 5-in. pumps.
26. 10 x 8-in. pumps.
27. Fifteen Krebs D6B-12° hydrocyclones (regrind cyclones).
28. Canadian Allis-Chalmers 8-ft dia x 12-ft regrind mill.
29. 5 x 5-in. pumps.
30. Fifteen Wemco Fagergren flotation cells, 66 x 60 x 29 in.
31. Conditioner, 12-ft dia x 12-ft high.
32a. Galigher Vacseal 2½-in. vertical pumps. (Pb-tails samples)
32b. 10x8-in. pumps (to No. 33).
33. Conditioner, 12-ft dia x 12-ft high.
34. Galigher Vacseal 1½-in. vertical pump.
35. Denver zinc rougher distributor, 8-ft dia.
36. Wemco Fagergren flotation cells, 66 x 60 x 29 in.—four banks of 17 cells each.
37. 10 x 8-in. pumps.
38. Conditioner, 8-ft dia x 8-ft high.
39. Galigher Vacseal 1½-in. vertical pump.
40. Denver zinc cleaner distributor, 5-ft dia.
41. Wemco Fagergren flotation cells, 66 x 60 x 29 in.—two banks (9 and 8 cells).
42. 6 x 6-in. pumps.
43. Wemco Fagergren flotation cells, 66 x 60 x 29 in.—two banks of 6 cells each.
44. 6 x 6-in. pumps.
45. Wemco Fagergren flotation cells, 66 x 60 x 29 in.—two banks of 6 cells each.
46. Sample agitator, 8-ft dia x 8-ft high.
47. 6 x 6-in. pumps.
48. Galigher Vacseal 2½-in. vertical pumps.
49. 10 x 8-in. pumps.
50. 10 x 8-in. pumps.
51. Fifteen Krebs D6B-12° hydrocyclones (regrind cyclones).
52. Canadian Allis-Chalmers 8-ft dia x 12-ft regrind mill.
53. 10 x 8-in. pumps.
54. Wemco Fagergren flotation cells, 66 x 60 x 29 in.
55. Conditioner, 12-ft dia x 12-ft high.
56. Galigher Vacseal 2½-in. vertical pumps.
57. 10 x 8-in. pumps.
58. Conditioner, 12-ft dia x 12-ft high.
59. Galigher Vacseal 1½-in. vertical pump.
60. Merrick Weightometer.
61. Accuray gamma gage.
62. Accuray gamma gage.

instead of being recycled to the head of the roughers, are treated in a separate circuit. This minimizes the effect of deleterious salts which, if introduced in fresh sphalerite, would hamper normal flotation.

The flotation uses fairly standard reagents, except perhaps the use of SO_2 as a zinc and pyrite depressant for the flotation of copper.

The copper-zinc metallurgy has given good results ever since start-up, and normally the circuit operates very steadily, according to Clarke.

Except for a few Denver cells on copper cleaning, Wemco Fagergren units are used for all the copper-zinc flotation.

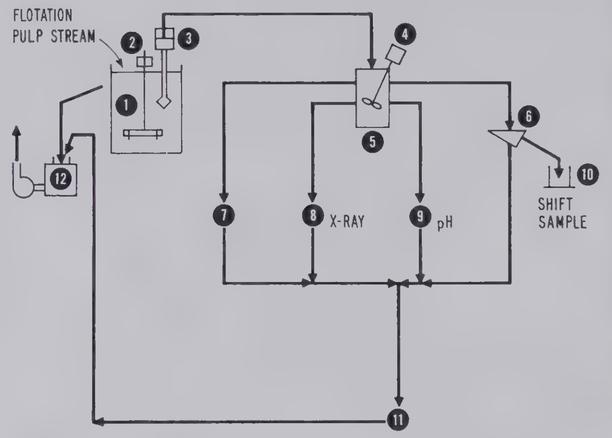
Flotation launders and pick-up launders are completely rubber, pumps are in duplicate, and almost all flotation cells have the automatic pulp level controllers that the company feels have worked exceptionally well.

Zinc-silver-lead ore ("C" ore). A typical head is 1.0% Pb, 0.4% Cu, 12.0% Zn, and 8.0 oz Ag per ton.

This ore is highly pyritic. In order to float the silver-lead-copper concentrate, a grind of 80% – 325 mesh is necessary. No primary roughers are in this circuit—the roughers take the fine feed direct from the grinding circuit after some aeration. The silver-lead-copper concentrate is cleaned three times and the reground middlings are floated again in a separate circuit. The main mineralogical problem is the interlocking of lead and silver in the pyrite.

In the zinc circuit, the rougher stage is followed by three stages of cleaning, with the reground middlings treated in a separate circuit. The sphalerite in this ore is intimately associated with the pyrite.

Continuous sampling system



Legend

1. Conditioner in flotation circuit.
2. Lightnin agitator.
3. Agitator Vacseal vertical sump pump.
4. Lightnin mixer.
5. Agitator, 2-ft dia x 3-ft high.
6. Denver automatic sampler—gang sampler.
7. Gamma gage controlling solids of #5.
8. Applied Research Laboratories' X-ray analyzer, plus Honeywell No. 21 computer.
9. Taylor pH instrument.
10. Vacuum filter.
11. Sala vertical pump.
12. Pump box.

After gaining wide experience at Canadian operations, Robert J. C. Tait, chief metallurgist of TGS's Metals Div. (right, with vice president Mollison), came to the company in 1964 and then began developing flowsheets for Kidd Creek.

Clarke said the main problem is the association of the silver and lead with the pyrite. Even when finely ground, there is still a large amount of silver and lead locked in the pyrite and not available for recovery. This varies considerably with the location of the ore in the mine.

With the more difficult ore, there are times when flotation has been carried out satisfactorily and still, because grinding had not been able to liberate a greater percentage, a desirable level of silver and lead recovery has not been reached. Finer grinding in most cases would only liberate diminishing amounts—and the flotation efficiency would also diminish.

Initially, Clarke reported, the silver-lead-zinc ore gave additional problems because of the presence of a large amount of soluble copper which interfered with selectivity. This is, however, slowly disappearing with depth. Graphite is also present but has not created too much of a problem.

Wemco Fagergren cells are used throughout this circuit and, according to TGS, perform excellently. All controls and other equipment on the copper-zinc flowsheet are duplicated on the lead-zinc circuit. SO_2 is also used here to depress pyrite and sphalerite during silver-copper-lead flotation, but most of the other reagents are quite standard.

Clarke feels this difficult-to-treat ore will be a problem for years to come.

Concentrate handling—also closely controlled

After flotation, Kidd Creek product passes to the concentrate handling section where it is prepared for shipment.

Concentrates from the flotation circuit are about 25% solids and 75% water. These go to their respective thickeners and have the water content reduced to about 30-35%.

On the concentrator's conventional thickeners, the torque is instrumented and the underflow is automatically controlled by a valve and gamma-gage density device. The thickener design was adequate and no operational problems have been encountered.

After passing through thickeners, the concentrates go to holding tanks (3-4 hour capacity) from which they are pumped to the filters.

Filters, each with its own wet vacuum pump, are also conventional. Filtrate pumps, however, have been completely eliminated since the filters are more than 32 ft above the thickeners and act as their own barometric leg in returning the filtrate back to the tanks. Filter operation has also been satisfactory.

Plant filters use a nylon filtering medium, and, under a vacuum of 25 in. of mercury, leave a filter cake on the cloth at a moisture of about 16-17%. This is quite wet for most filtering operations, but, because of the fine nature of the concentrates (95-96% —325 mesh), is about the minimum moisture that can be obtained.

Filter cake is fed into the gas-fired dryers where the moisture is further reduced (as steam) to 6%, Clarke said that 6% moisture is ideal—concentrates do not dust and, in winter, will not freeze solidly in the rail cars.

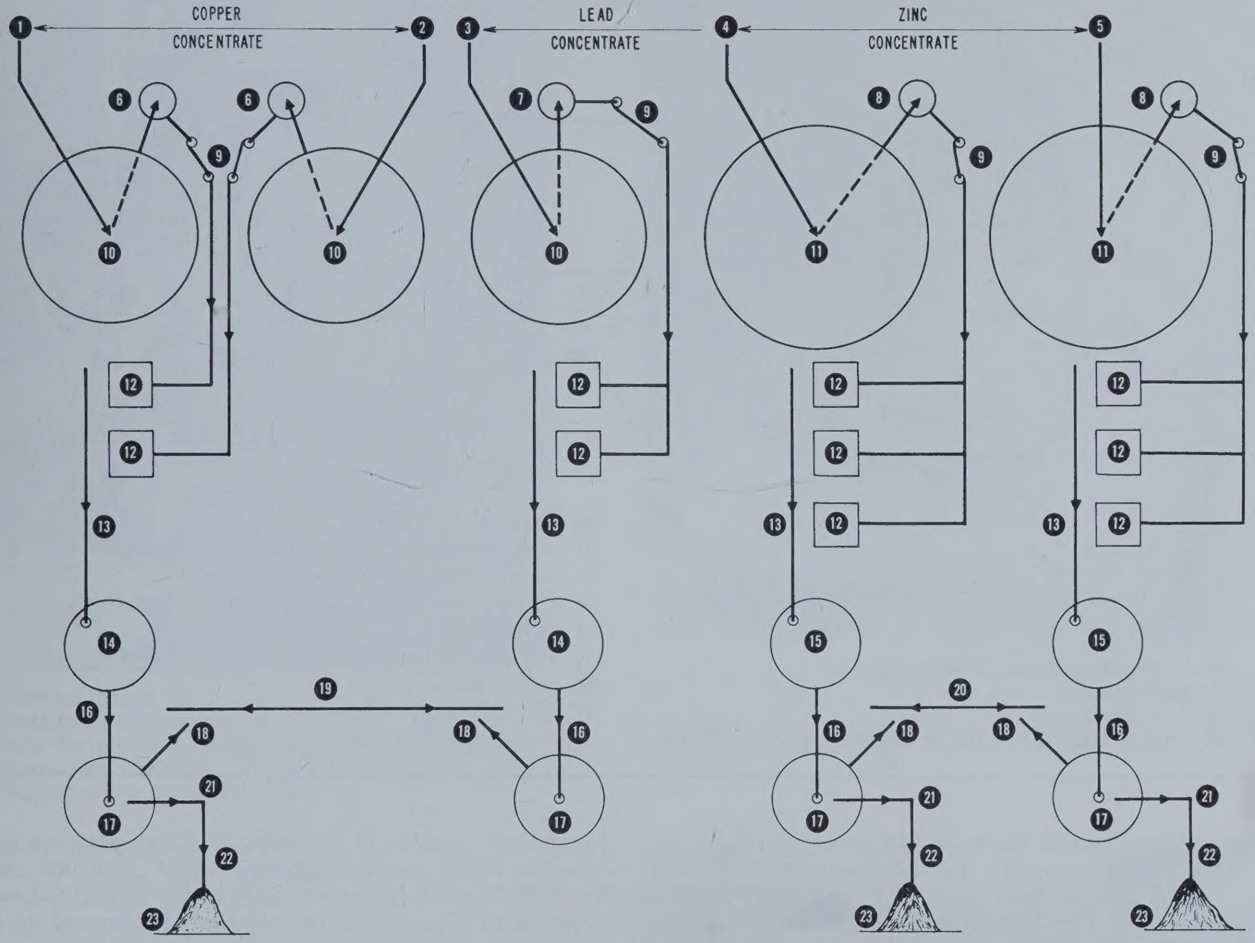
The dryers are vertical hearth units—a dryer version of the Nichols Herreshoff roasters that have been used in smelters for years. Texas Gulf selected them over the conventional kiln-type rotary dryer for the following reasons:

1) Kidd Creek's sticky, difficult-to-feed concentrates could best be handled by the hearth dryer;

2) The concentrates' fine size would present a dust problem and most likely overload a rotary dryer's dust collecting equipment. The TGS staff felt that the hearth dryer's reduced air velocity would keep dust levels in check:

3) Since it has a static shell, the hearth dryer could

Kidd Creek concentrator—concentrate handling
(composite plan)



Legend

1. Thickener feed—copper concentrate from "A" division.
2. Thickener feed—copper concentrate from "B" division.
3. Thickener feed—lead concentrate.
4. Thickener feed—zinc concentrate; low silver.
5. Thickener feed—zinc concentrate; high silver.
6. Holding tank—12 x 12 ft } with Lightnin agitators.
7. Holding tank— 8 x 8 ft } with Lightnin agitators.
8. Holding tank—14 x 14 ft.
9. Canadian Allis-Chalmers two-stage SRL pumps, 3 x 3 in., 1,400 rpm.
10. Thickeners, 60-ft dia, 12.5-ft deep.
11. Thickeners, 100-ft dia, 12.5-ft deep.
12. Eimco 8-ft, 10-in. Agidisc filters, 10 sectors, 6 disks.
13. Conveyor, dryer feed; 24 in. wide, 55 fpm.
14. Nichols-Herreshoff vertical hearth dryer; 7 hearths, using 5.
15. Nichols-Herreshoff vertical hearth dryer; 9 hearths, using 5.
16. Conveyor, dryer discharge; 24 in. wide, 55 fpm.
17. Dry concentrate holding bins; 30-ft dia. 700 tons live capacity.
18. Loadout conveyor; 48 in. wide, 208 fpm.
19. Shuttle conveyor—copper, lead to railway cars; 48 in. wide, 165 fpm.
20. Shuttle conveyor—zinc (low and high silver) to railway cars; 48 in. wide, 165 fpm.
21. Retractable conveyor; 24 in. wide, 55 fpm.
22. Emergency loadout conveyor; 24 in. wide, 55 fpm.
23. Emergency stockpile.

be highly instrumented for accurate drying control;

4) When treating the type of sulphidic material found at Kidd Creek, hearth dryers eliminate fire hazards inherent in the operation of rotary dryers.

These dryers have worked well at Kidd Creek. Since feeding presents no problems, Clarke reported, there is a very light load of dust to the cyclone and scrubber (about 5% circulating load), resulting in clean discharge gas.

Initially there were problems with the mechanism of the rabble drive, but these have all been corrected. Clarke added that the instrumentation-controlled units give an extremely uniform product.

The 6% moisture concentrates are conveyed to storage bins of about 16-hours capacity from which they are loaded into railway cars for shipment to markets.

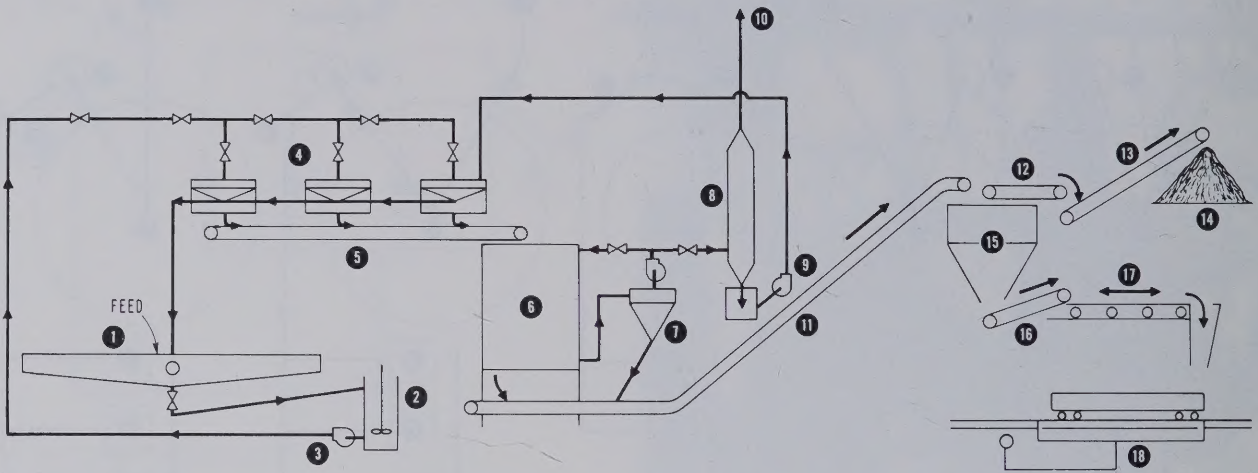
When the load-out was designed, the company decided to install a system which would call for loading on day shift only, thereby making it possible to have maximum supervision. This has worked out well—a 90-ton car of concentrates can be tared, loaded and weighed in about eight minutes. Normally, in one day, there are about six gondolas of copper concentrate, nine cars of silver-zinc concentrate, nine cars of high zinc concentrate, and three cars of lead concentrates, making an average of 27 gondolas out per day.

Once the cars are loaded, the surface of the concentrate is sprayed with a liquid which forms a plastic skin over the material and prevents dusting.

Storing and distributing reagents

Except for revisions to the lime loop and the addition of SO_2 about three months after start-up, the well-de-

Kidd Creek concentrator—concentrate handling
(typical elevation, each of four circuits)



Legend
1. Thickener.
2. Holding tank, with Lightnin agitators.
3. Canadian Allis-Chalmers SRL two-stage pump, 3 x 3 in., 1,400 rpm.
4. Eimco 8-ft, 10-in. Agidisc filter.
5. Conveyor, 24-in. wide, 55 fpm.
6. Nichols-Herreshoff vertical hearth dryer.
7. Duclone cyclone.
8. Ducon scrubber.
9. Canadian Allis-Chalmers SRL two-stage pump, 3 x 3 in., 1,400 rpm.
10. Exhaust to atmosphere.
11. Conveyor, dryer discharge, 24 in. wide, 60 fpm.
12. Retractable conveyor, 24 in. wide, 208 fpm.
13. Conveyor, emergency loadout, 24 in. wide, 55 fpm, 42 tph.
14. Emergency stockpile.
15. Holding bin.
16. Loadout conveyor.
17. Shuttle conveyor.
18. Railway track-weigh scale.

signed reagent system has been functioning perfectly.

At the reagent unloading deck, materials such as quicklime, soda ash and bulk super-fine copper sulphate are handled by a Fuller-Dracco combination suction-pressure pneumatic conveying system which puts them into their respective storage bins.

A pumping station is provided for unloading rail tank cars and tank-trucks of concentrate chemicals into the 10,000 or 20,000-gal storage tanks. Some of these are zinc sulphate cyanide, Dowfroth 250, Promoter R208 and Promoter R211. There are also facilities for storing drummed reagents such as methyl isobutyl carbinol, Dow Z200, and Dow Xanthate Z14.

The lime is slaked to hydrated lime in a ball mill-cyclone arrangement and pumped in a pressurized closed loop to solenoids where lime addition to the circuit is controlled automatically by pH meters. All other reagents except Z200 and methyl isobutyl carbinol are mixed with water to a desired and accurate concentration in their own tanks equipped with Lightnin mixer impellers.

All reagents, whether mixed with water or concentrated, go to the individual holding tanks where a pump close-circuits them with their individual tanks above the rotometer room in central control. Overflow from the head tank goes by gravity back to the holding tank, thus maintaining the constant head in the head tank which is necessary for a constant flow through the rotometer.

All reagents other than lime are metered through these rotometers in central control, and the metered chemical conveyed to the point of addition in plastic pipes.

Clarke said the entire reagent system has worked exceptionally well from the beginning.

When dealing with complex circuits so finely balanced into one another as at Kidd Creek, there was a clear understanding from the outset that the concentrator's sampling system must function effectively.

Ray Clarke said the sampling system was designed into the mill by installing homogeneously mixing agitators on all full product streams to be analyzed. These agitators each have a 50-gpm pump submersed about 3 ft into them which pulls a sample continuously to the centralized analyzing room. Once here, the samples are directed to the X-ray, pH units and sample filters.

Nothing functions without central control

During this short survey of concentrator highlights, central control has been mentioned repeatedly. The reason, obviously, is that no stage of processing at Kidd Creek's plant can operate effectively without reporting to—and being under the supervision of—central control. And the influence of the plant's nerve center reaches out to the mine and connecting railroad. It is here that the make-up of the ore streams and the effectiveness of the concentrator's treatment of them is checked. Here also is where any discrepency from the desired analyses is spotted and rectified.

TGS is both proud of and dependent on central control and its incorporated analyzing systems; without these elaborate automatic controls, Kidd Creek's success at mining a segregated, complex orebody, and pulling mineral values from it, would simply not have been possible.

Central control, almost dead center in the main mill and crusher building, is itself actually a five-story building. The bottom level has the cable rooms for electrical distribution. The second level has the 550-v MCC (motor control center) for all flotation cells, pumps, etc. This room and the cable vault underneath it are 480 ft long! The third level, at the operating floor for the grinding and flotation circuits, consists of two instrumentation rooms. The fourth level—the actual central control—consists of an instrument repair bay, X-ray room, main panel room, shift foreman's office, and reagent rotometer room. The fifth level has the sample room, reagent head tank room and air conditioning equipment.

The main panel room has the computer and computer

Experience based on a wide range of electrical and mechanical assignments at scattered mining operations in Ontario and Quebec during the past 40 years has prepared Gerard F. O'Halloran for current duties as maintenance superintendent.

When Stephen Y. Mostowy, mill superintendent, joined TGS in 1965, he brought with him five years of plant metallurgical experience at Quemont Mining Corp. Ltd., Quebec, and eight years mill experience at Normetal Mining Corp., also in Quebec.

console, the operator's desks with a type-out typewriter for each of the three circuits, plus one spare, and the five operational panels—one for each circuit, one for the crushing plant, and a service panel.

Clarke said that under present operating conditions, all information is shown on the panels so that a central control operator can read them and take appropriate action.

All X-ray assays are on the typewriter; the operator goes into the reagent rotometer room and makes appropriate reagent adjustments to obtain maximum metallurgy.

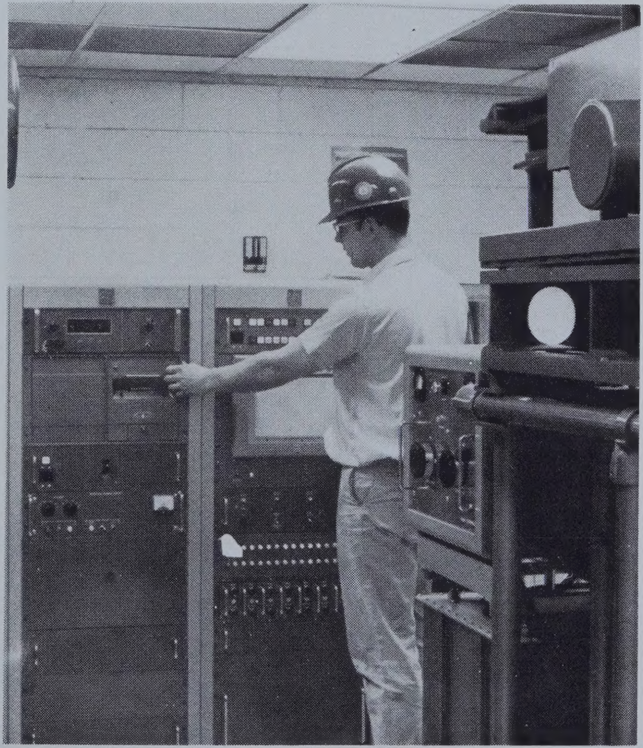
Each circuit has five pulp streams for assay. Each stream represents a stage in the process and is assayed for copper, lead, zinc, iron and silver. A complete set of copper-zinc assays comes in every 12 minutes, and a lead-zinc set comes in every six minutes.

Programmed to carry out the entire sampling system, Kidd Creek's computer transmits findings to the control room operator, directs the analyzer to go to the next process stream, and then double checks to see if the analyzer actually has gone to the proper stream and is correctly carrying out the spectroscopic analyses.

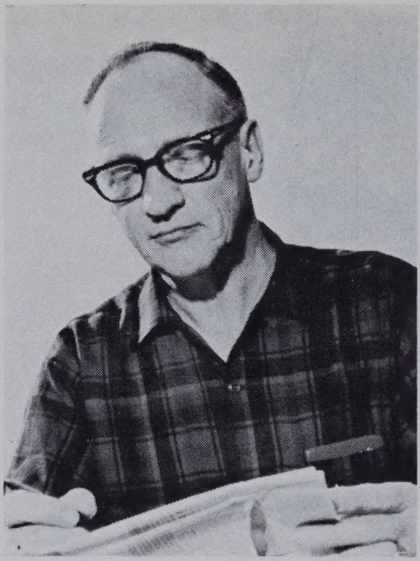
As a further check on the system, calibration briquettes of known composition are analyzed periodically by the X-ray-computer circuit. TGS said that this is carried out without interrupting normal plant operation.

In addition to handling X-ray data, the Kidd Creek computer monitors and annunciates all grinding mill and synchronous motor bearing temperatures, all tonnages from the crushing, grinding and concentrates' handling sections, and types out the information on demand, or every eight hours automatically.

The great care with which Texas Gulf designed and installed its formidable instrumentation network has been matched by the time and money spent making sure the operating staff at the concentrator can work comfortably and efficiently.

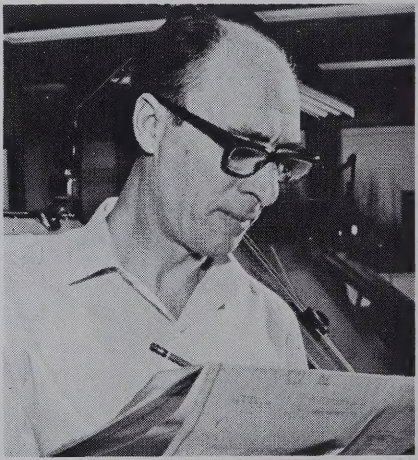


Varying compositions of the concentrator's product flows are recorded by this X-ray quantometer in central control.



Chief accountant Donald P. Taylor first came to Timmins in 1936, and then gained wide finance experience at neighboring mines. His first TGS job was to set up accounting procedures at the mine.

The welfare of the Kidd Creek work force is the prime responsibility of Donald F. Grenville, personnel and industrial relations superintendent. He is standing in front of the most striking interior feature of the new administration building—a lobby wall composed of high-grade pit ore.



London-born Alan G. Perry, superintendent of engineering, came to Canada in 1951. Before joining TGS in 1965, he had, among other things, worked in Greenland for the U.S. Government.

Of prime importance here is a modern communications system. A public address set-up allows the central control operator to page any person in the plant. Direct "hot lines" throughout the mill permit each operator to reach the proper panel in central control without any delay. This is supported by dial phones in all rooms and offices.

In addition, the central control room has large windows to make it possible for operators to see all of the grinding floor, flotation floor, and thickeners.

Disposing of tailings has not been an easy matter at Kidd Creek—the land around the concentrator area is absolutely flat.

About one square mile of land half a mile from the mill serves as the present tailings area. Its perimeter is completely diked with gravel and sealed with tailings on the inside to prevent seepage. Decant towers for the removal of clean water are distant from the point where the pulp tailings are discharged.

Two 18-in. lines carry the tailings to the area; one is a spare in case of failure.

Clarke said the rise of solids per year over the whole tailings area has been estimated at 1 ft.

He added that the present tailings removal system is working satisfactorily — there have been no problems keeping the decanted effluent free of both solids and chemicals.

The plant's water supply comes from the Federickhouse River, about 3½ miles away. The pumphouse at the river delivers water to a 750,000-gal. storage tank at the mill. According to Clarke, this is enough for about one hour's production, and has so far presented no problems.

Booster pumps in the mill raise water pressure to either 60 psi or 90 psi, depending on application. There is also, Clarke said, a source of 130-psi water for pump glands.

Kidd Creek's major asset

Credit for success at Kidd Creek has variously been given to factors such as the uniqueness of the orebody, the methods of treating it, and the quality of equipment at mine and mill. What the Texas Gulf officials are always quick to add is that nothing would have succeeded without people.

Metals Division vice president Richard Mollison continually lists as a major asset at Timmins the high-caliber work force the company has been able to assemble for all phases of the project.

The fact that the personnel at Kidd Creek are superior is certainly important. But just as important is the personnel's realization that, from the outset, Texas Gulf has done everything possible to foster a favorable working environment.

Approximately 630 persons are now employed at Kidd Creek—all are salaried. Annual bonuses are paid as declared by the board; in 1968, the bonus was 2½% of annual salary plus $10 for each year of service. In addition, the company provides a constantly-reviewed package of fringe benefits.

Fringe benefits can come in many forms. At Kidd Creek, one of these is the organized campaign to promote safety on the job. The result is that the operation has an accident frequency of 4.2 for each million man hours, compared to a much higher average for all mines in Ontario during 1968.

In the October 1968 issue of Golden Triangle, the company's magazine, Dr. Charles F. Fogarty, president of Texas Gulf, said that . . . "it is my objective to help make TGS the largest company in the world in natural resources and related processing fields."

A good deal of his optimism comes from the support he knows he'll get from Kidd Creek.